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FEASIBILITY STUDY OF REMEDIAL ACTION ALTERNATIVES

ACUSHNET RIVER ESTUARY ABOVE COGGESHALL STREET BRIDGE NEW BEDFORD SITE BRISTOL COUNTY, MASSACHUSETTS

EPA WORK ASSIGNMENT NUMBER 28-1L43 CONTRACT NUMBER 68-01-6699

NUS PROJECT NO. 0725.16

AUGUST 1984

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Park West Two
Cliff Mine Road
Pittsburgh, PA 15275
412-788-1080

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SUBMITTED FOR NU

Joseph G. Yeasted
JOSEPH G. YEASTED
PROJECT MANAGER

APPROVED:

E. Dennis Esler for
DONALD SENOVICH
MANAGER, REMEDIAL PLANNING

CONTENTS

CONTENTS (CONTINUED)

CONTENTS (CONTINUED)

TABLES

FIGURES

FIGURES (CONTINUED)

EXECUTIVE SUMMARY

Authorization for Study

The United States Environmental Protection Agency (EPA), under authority promulgated by the Comprehensive Environmental Response, Compensation, and Liability Act (i.e., the Superfund Act), assigned the New Bedford Site in Bristol County, Massachusetts to its National Priorities List of hazardous waste sites in July, 1981. The New Bedford Site was nominated by the Commonwealth of Massachusetts as its first priority site for the list due to widespread contamination by polychlorinated biphenyls (PCBs) in the New Bedford Harbor and surrounding areas. Under EPA Work Assignment No. 28-1L43, issued on August 24, 1983, the Remedial Planning Office of NUS Corporation (NUS) was authorized to prepare a *Work Plan for a Remedial Investigation and Feasibility Study for the New Bedford Site*. A critical element of the Work Plan was a fast-track Feasibility Study of remedial action alternatives for the highly-contaminated mudflats and sediments of the Acushnet River Estuary north of the Coggeshall Street Bridge. This fast-track study was requested by the EPA and the Commonwealth of Massachusetts since the extremely high levels of PCBs in these locations (i.e., the "hot spots") pose an immediate risk to public health, public welfare, and the environment, and because contaminants are migrating from this area. On October 18, 1983, NUS received interim authorization to proceed with the fast-track Feasibility Study.

Study Objectives

The objectives of the overall remedial action program for the PCB hot-spot areas of the Acushnet River Estuary are the following:

- To decrease the immediate risk to public health. The high levels of PCBs in the hot-spot areas currently pose a potential public health threat due to the hazard associated with direct contact with the contaminated mudflats and sediments, uptake of PCBs through the ingestion of contaminated fish and shellfish, and respiratory inhalation of PCBs in the volatile and particulate forms.

- To decrease the impact on aquatic and terrestrial organisms and resources within the upper harbor that have been contaminated by high levels of the chemicals. These elevated levels and the impacts on public health and welfare associated with contaminated animal and plant communities will continue until the contaminants are rendered unavailable to the food chain and plants.

- To decrease the potential for contaminant migration from the hot-spot areas to other less contaminated or uncontaminated areas. If left unremediated, the contaminants will spread until a greater portion of the aquatic community becomes unfit or unavailable for the food chain and ultimately for human consumption. The progressive movement of contaminated sediments and surface waters from the upper estuary into New Bedford Harbor and Buzzards Bay also exacerbates the current water quality problems and related socioeconomic problems in these downstream water bodies.

The objective of the fast-track Feasibility Study is to comprehensively evaluate potential alternatives for remediation of the hot-spot areas in relation to engineering feasibility criteria, public health and environmental impacts, costs, and various other considerations such as future risk and community acceptability and impacts. No single alternative was found to be free of engineering constraints, environmental effects, and potential community impacts. Therefore, several alternatives to achieve hot-spot remediation in relation to the imposed evaluation criteria are developed so that the EPA, other involved Federal agencies, the Commonwealth of Massachusetts, and the affected communities can properly assess the feasible alternative actions toward the ultimate goal of remedial action selection and implementation.

Sources of Information and Data

Due to the perceived urgency for remediation of the hot-spot areas, the fast-track Feasibility Study was to be based on the extensive informational base currently available from previous engineering and scientific investigations and data collection efforts. Literally scores of studies related to the New Bedford Site have been completed and were reviewed during the course of this work. These range from particularly relevant investigations of potential remedial actions and data collection efforts to define the nature and extent of contamination, to more general studies of harbor development and regional resources. Although these studies did not focus on the hot-spot areas, most did provide some level of data or information used in the fast-track Feasibility Study.

Numerous general references on PCBs and engineering issues were also utilized in the course of this study. Of particular note is a large collection of documents published by the Corps of Engineers as part of their ongoing research program on various aspects of dredging contaminated sediments. An Interagency Task Force composed of representatives of involved Federal State, and local agencies performed interim reviews of study methodologies and results and provided input on regulatory and policy issues.

The principal source of the chemical data used in the fast-track Feasibility Study was the data management system developed and managed by Metcalf and Eddy under a separate EPA contract. The chemical data base for the Acushnet River Estuary/New Bedford Harbor/Buzzards Bay system contains more than 5,000 individual data entries, representing approximately 3,700 PCB analyses and 1,400 analyses of other parameters, primarily heavy metals. It reflects the efforts of 21 data collecting agencies and 23 analytical labs over the past ten years. Almost all of the data contained in the file are from the Acushnet River Estuary, New Bedford Harbor, and Buzzards Bay.

Project Setting

The study area for the fast-track Feasibility Study encompasses three geographical areas. The geographic focus is the hot-spot area itself, which for purposes of this study is considered to be the Acushnet River Estuary extending northward from the Coggeshall Street Bridge to the Tarkiln Hill Road Bridge. Also of interest to the analysis of the problem and remedial actions are those areas currently impacted by the presence of contaminants in the upper estuary. These areas include the remainder of New Bedford Harbor and Buzzards Bay, and the adjacent communities of New Bedford, Acushnet, and Fairhaven. A third geographic area, which includes the communities within an approximate 10-mile radius of New Bedford Harbor, is considered part of the study area only as it relates to the identification and analysis of potential disposal sites for contaminated sediments that would be dredged from the estuary under certain remedial action alternatives.

In 1929, the first of two major electrical component manufacturers, Cornell-Dubilier Electronics, began operation in New Bedford. The second, Aerovox Industries, Inc., began operation in the 1930's. These industries are housed in old textile mill houses located on the banks of the Acushnet River Estuary and both remain in business today. Their use of PCBs in the manufacture of electronic capacitors has brought a series of contamination problems to the area. Testing revealed that Aerovox and Cornell-Dubilier were discharging wastewaters containing PCBs directly to the Acushnet River/New Bedford Harbor/Buzzards Bay system. Indirect discharges also occurred from these industries by combined sewer overflows, via the New Bedford municipal wastewater treatment facility, and from surface water runoff.

Toxic metals such as copper, chromium, zinc and lead were also contributed by metals manufacturing and textile dyeing operations over the past 80 years. The disposal of these wastes by industries has led to severe environmental contamination of the estuary and harbor.

Current Levels of Environmental Contamination

PCB contamination has been found in several environmental media in the Acushnet River Estuary, including the biota, sediments, water and air. The biotic community of the Acushnet River Estuary and the overall harbor system has been severely degraded by PCB contamination. In September, 1979, the Commonwealth of Massachusetts closed the esturary to all fishing due to the PCB contamination. Median PCB concentrations for numerous species of fish and shellfish are well above the recently redefined Federal Drug Administration (FDA) action level of 2 ppm (lowered from 5 ppm). The action level is the PCB concentrtion in the edible portion of fish considered safe for human consumption. Eels seem to be the most heavily contaminated species in the harbor. All samples collected to date had PCB concentrations exceeding 11 ppm with a mean value of 131 ppm (32 samples), and several eel samples exceeded 500 ppm. Lobsters were also found to be heavily contaminated. Of 183 lobsters sampled between 1976 and 1980, both the median PCB concentration of 4.9 ppm and the mean concentration of 8.7 ppm exceed the FDA action level. The maximum concentration found in lobsters was 84 ppm.

The most severe sediment contamination within the study area is the western and northern parts of the estuary, where PCB concentrations typically exceed 1,000 ppm (dry weight) and have been found to exceed 100,000 ppm in localized areas. Elevated concentrations of toxic metals are also found in the sediments, including copper (>1,000 ppm), arsenic (>50 ppm), lead (300-500 ppm), zinc (>600 ppm), mercury (>2.5 ppm), chromium (400-500 ppm), nickel (>150 ppm), and cadmium (>20 ppm).

In the short-term, concentrations of PCBs in the water column and air are not as significant of a concern, but are elevated compared to background values. These media represent a continued long-term source of contamination to the food chain and ambient atmosphere, respectively. As long-term sources of contamination, these areas need to be remediated.

The No-Action Alternative

Under the no-action alternative, the current levels of environmental contamination will be sustained and the contaminants will be further dispersed. Many species of fish and shellfish already exceed the FDA limit of 2 ppm PCBs in the edible portion, while several others have average concentrations close to the FDA limit. Whether concentrations in these species will increase, remain at current levels, or decrease under the no-action alternative depends on the relative rates of PCB uptake and depuration. It is expected that species within the hot-spot areas will continue to bioaccumulate PCBs and that concentration levels may remain at the currently elevated values and could even progressively increase. The no-action alternative will likewise cause a continued uptake of PCBs and metals by birds, waterfowl, and other terrestrial animals that feed in the Acushnet River Estuary, along its tidal flats, and within the contiguous wetlands. The aquatic vegetation along the shorelines and within wetland areas are currently impacted by contaminants in the water column and sediments, and this problem is expected to remain for a long period of time. Volatization of PCBs and the release of PCBs and metals attached onto particulates will continue from the hot-spot areas under the no-action alternative.

Due to the magnitude and uncontrolled nature of the existing environmental contamination in the Acushnet River Estuary, the no-action alternative represents the highest level of risk to public health and welfare when compared to the proposed remedial action alternatives. The potential pathways of human exposure to PCBs through the air, water, sediment, and biotic environments pose a persistent and accumulative risk for an indefinite period if no remedial action is taken. The ingestion of fish and shellfish from the estuary and harbor (despite the current ban) would continue as a critical exposure pathway.

There have been some economic losses because of the official closure of the upper estuary to fishing, including reduced sports fishery and related activities (e.g., boat rental) and the costs to community residents resulting from the absence of local catch in their routine diet. Other potential socioeconomic impacts that will be maintained under the no-action alternative include depressed property values in the vicinity of the harbor, the lack of impetus to redevelop the waterfront properties, and a reduced recreation value. The principal economic effects of harbor contamination are associated with commercial activities in downstream areas. These include the closure of the harbor to fishing and the taking of lobsters, constraints on development plans due to the expense of disposal of heavily contaminated dredge spoils, and the potential long-term effects of similar limitations on maintenance dredging. The continued release of PCBs and metals to less contaminated downstream areas under the no-action alternative will perpetuate and exacerbate the existing conditions and associated impacts.

Initial Screening of Remedial Action Technologies

The remediation of the hot-spot areas in the Acushnet River Estuary is a complex undertaking due to the wide range of interactive technical, regulatory, socioeconomic, environmental, and health issues. For this reason, the fast-track Feasibility Study had to be comprehensive in the types of potential remedial actions considered. The number of potential technologies and combinations thereof are excessive, and thus it became necessary to undertake a phased evaluation and selection process.

The purpose of the initial screening was to identify and assess all existing technologies applicable to the remediation of PCB contamination, and to eliminate upfront those technologies that are not technically feasible for the problem and local conditions involved or that do not have a proven performance record in the application intended. The latter criterion is based on the National Contingency Plan, which requires that only proven technologies should be relied upon when feasible and cost-effective.

More than 60 percent of all technologies initially identified were eliminated in the initial screening process. Those that remained for the second phase of screening can be categorized as follows:

- No-Action Alternative

- Non-Removal Actions: Hydraulic control using sheet piling or a bypass channel, in conjunction with in-situ containment of the contaminated sediments.

- PCB Removal Actions: Contaminated sediment removal by dredging with direct disposal or incineration before disposal into an upland landfill, a shoreline disposal site, or an existing, out-of-state chemical landfill.

- Support Actions: A reduced number of technologies for solids dewatering, sediment dispersal control, surface water control, and water treatment.

Secondary Screening of Remedial Action Technologies

In the initial screening of technologies, no consideration was given to a comparative evaluation of the technologies to determine the "most appropriate" among them. A secondary screening was therefore performed on the remaining technologies toward the objective of selecting only the most cost-effective technology in each grouping. The groupings requiring a secondary screening included the hydraulic control, solids dewatering, sediment dispersal, and sediment dredging technologies.

Based on the results of the secondary screening, the following technologies were selected as the most cost-effective for use in the development of remedial action alternatives:

- Hydraulic Control: Lined earthen and rockfill channel.

- Solids Dewatering: Settling lagoon.

- Sediment Dispersal Control: Sheet piling or double silt curtain (depending on intended use).

- Sediment Dredging: Cutterhead dredge (bucketwheel type).

Development of Remedial Action Alternatives

The screening processes focused on the applicability and comparative value of individual remedial technologies. The next step in the phased study approach was to combine the remaining technologies into remedial action alternatives. Four potential remedial action alternatives were developed in addition to the no-action alternative. These are:

Hydraulic Control with Sediment Capping (Estimated Present Worth Cost: $24.6 million) - This alternative involves the construction of a lined earthen and rockfill channel along the western shoreline to bypass the freshwater flows of the Acushnet River Estuary from a point upstream of the hot-spot areas to a point below the Coggeshall Street Bridge. The purpose is to isolate the contaminated sediments from the resuspension and transport action of the river flow. Embankment heights will be constructed to elevations suitable to prevent overtopping during flood conditions,
except near the harbor opening beneath the Coggeshall Street Bridge where the embankment height will be lowered to allow a tidal exchange between the lower harbor and the estuary. The harbor bottom in the remaining open-water areas will be covered with clean sediments in order to isolate the contaminated sediments. Sediment dispersal control will be implemented prior to construction.

Dredging with Disposal in a Partially Lined, In-Harbor Containment Site - (Estimated Present Worth Cost: $27.8 million) - In this alternative, contaminated sediments will be dredged from the estuary and disposed in an in-harbor containment site along the eastern shore in the northern part of the estuary. Before dredging begins, sediment dispersal control will be installed at the harbor opening beneath the Coggeshall Street Bridge. The cove on the western shore of the upper harbor will be developed into a temporary containment site by construction of an earthen retaining embankment. Sediments from the proposed location of the in-harbor containment site embankment will be dredged and pumped to the temporary containment site. Next, the in-harbor containment site embankment will be constructed of earthen materials and will isolate the containment area from the Acushnet River Estuary and harbor waters. The walls of the containment area will be lined. However, the bottom will be unlined. Dredging of the remaining areas outside of the embankment in the upper harbor will then proceed with the spoils being pumped to the permanent containment site; previously dredged sediments contained in the temporary site will be concurrently pumped to the permanent site. All supernatant water in both containment sites will be removed for subsequent treatment. Finally, the permanent containment site will be capped to further isolate the contaminants.

Dredging with Disposal in a Lined, In-Harbor Containment Site - (Estimated Present Worth Cost: $79.5 million) - This alternative is similar to that just described, except that an impermeable membrane liner will be placed beneath the containment site. Such an alternative will require that contaminated sediments beneath the proposed in-harbor containment site be removed and the site dewatered prior to liner placement. The material dredged from underneath the embankment and inside the containment area will be stored in the temporary containment site until completion of the liner placement. All contaminated sediments will then be disposed in the containment site, as above.

Dredging with Disposal in an Upland Containment Site - (Estimated Present Worth Cost: $44.0 million) - This alternative involves dredging the contaminated sediments from the estuary with disposal in an upland containment site. Initially, a containment facility for the final disposition of contaminated dredge spoils will be developed at a suitable upland location. As with the other dredging alternatives, sediment dispersal control will be installed at the mouth of the upper harbor before in-harbor operations begin. A temporary containment site will be constructed in the cove on the western shore of the upper harbor. Harbor sediments will be dredged and pumped into the temporary site. Upon adequate dewatering, the contaminated sediments will be removed from the lagoon and transferred to trucks for transportation to the upland disposal site. All decanted water will undergo treatment to remove residual contaminants. When all sediments have been disposed into the containment facility, the landfill will be capped.

For the dredging alternatives, consideration was given to either incinerating all sediments with PCB concentrations exceeding 500 ppm prior to disposal, or removing such highly contaminated sediments to an existing, out-of-state landfill. Each of these options was ruled out due to the extremely high costs, the length of time required to complete the remedial action, and the additional impacts and risks involved.

Evaluation of Remedial Action Alternatives

Practically speaking, each of the aforementioned remedial action alternatives can be considered to achieve complete isolation and/or removal of the PCBs and metals from the hot-spot areas. A small percentage of the contaminants will remain in the sediments due to an inherent operational inefficiency, and in some localized areas low levels of contaminants may be present at a depth below that dredged. The concentration of PCBs remaining in the estuary sediments should, on the average, be less than the most stringent target value of 1 ppm. A similarly effective removal and/or isolation of heavy metals will concomitantly be achieved.

The implementation of each alternative will have significant beneficial impacts on public health, public welfare, and the environment. Upon project completion the following conditions should be satisfied:

- Contaminants will not be directly exposed to the atmosphere to contribute to airborne contamination.

- The upper estuary sediments will either be removed or covered by a clean cap so that direct contact with highly contaminated materials will be prevented.

Certificate of Authenticity

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Operator

Operator

- The contribution of contaminants to the food chain that initiates in the benthic organisms and bottom feeders will be eliminated.

The risk to humans posed by contaminated fish and shellfish will continue for a period of time until the organisms cleanse themselves through natural processes. The rate of depuration is species-dependent, and is being investigated in a companion study. It is expected that at least several years will be required before the heavily contaminated species in the estuary will satisfy the current FDA level of 2 ppm for PCBs.

Each of the four remedial action alternatives will remove or isolate the PCBs and metals in the Acushnet River Estuary upstream of the Coggeshall Street Bridge so that their transport to the harbor and bay is prevented. This will avoid the compounding of the contamination already in the harbor and bay, thereby reducing the exacerbation of public health, public welfare, and environmental impacts.

The risk of long-term contaminant releases is low for any of the four alternatives if the physical components are properly engineered and constructed. The differentiation among the four alternatives is related primarily to the previously mentioned costs and the respective adverse impacts. The hydraulic control and sediment capping alternative would most severely impact aquatic life due to the permanent channeling of the Acushnet River Estuary and the consequential disruption of migratory patterns. Capping of the sediments will destroy the existing benthic community and will eliminate or otherwise impact the shallow water wetlands along the shoreline. Several short-term impacts, such as increased noise levels and truck traffic, will also occur during the construction phase.

Sediment dredging imposes the risk of resuspending contaminated sediments in the water and releasing contaminants to the air, thereby increasing the potential for contaminant dispersal and downstream migration. Except for the possible resuspension of PCB-laden oily films, which can be at least partially controlled, there is a low probability that a significant contaminant suspension or release will occur. Dredging will destroy benthic organisms and will temporarily disrupt other aquatic species, but the ecological community will likely reestablish itself upon project completion.

The principal negative impact of an in-harbor disposal site is the permanent loss of salt marshes along the eastern shoreline. For the partially lined site, groundwater will be free to move through the site, but it is unlikely that PCBs or metals will be mobilized. (Note that there is no known use of the groundwater in this area due to its saline nature.) During active operation, contaminated sediments and supernatant water will be exposed to waterfowl and mammals, and an increased release of contaminants to the atmosphere could occur. The temporary sediment storage area will have similar impacts on the western cove.

Disposal in an upland site will not totally eliminate all impacts to the salt marshes, since these marshes are likely to be heavily contaminated and will require dredging. Additional impacts of this alternative are the noise and risk associated with the truck transport of the contaminated sediments, the introduction of contaminated materials to an environment currently removed from the problem, and the overall community impacts associated with an upland chemical landfill.

Conclusions and Recommendations

Through a phased evaluation of technologies and combinations thereof, the no-action alternative and four remedial action alternatives were retained for final evaluation in this fast-track Feasibility Study. The development and final selection of these alternatives were based not only on technical merit and cost-effectiveness, but also in response to uncertainties as to how the policy and regulatory framework governing any remedial action of the hot-spot areas would be interpreted and applied.

Serious public health, public welfare, and environmental problems and impacts would persist under the no-action alternative. For this reason, the no-action alternative is not recommended for the hot-spot areas. Its inclusion in the final analysis has, however, provided an assessment of the current problem and impacts for use as a comparative baseline in the evaluation of the remaining alternatives.

The alternative of hydraulic control and sediment capping is the only option which isolates rather than removes the contaminated sediments. This alternative is the least costly of those evaluated, and reduces the potential for resuspension of the contaminants and the associated risk when compared to the dredging alternatives. The beneficial effects of isolating the contaminants must be weighed, however, against the resultant permanent alteration of the hydrology and aquatic resources of the estuary above the Coggeshall Street Bridge. The need to extend the channel into the deeper portions of the estuary near the bridge opening and the placement of an effective underwater sediment cap introduce particularly difficult engineering features to this alternative. As a result, the long-term integrity of the isolation alternative may be reduced in comparison to the removal options. An additional negative feature is that the potential future need for the disposal of contaminated sediments from the lower harbor cannot be incorporated into this alternative. In conclusion, hydraulic control and sediment capping would most likely be the recommended alternative only if policy and regulatory constraints are found to prohibit or significantly reduce the cost-effectiveness of the removal and disposal of contaminated sediments in either an in-harbor or upland site.

The two dredging and in-harbor disposal alternatives achieve the study objectives by the physical removal of the sediments to an engineered and controlled environment. Such alternatives are more consistent with the objective to achieve a permanent remedy to prevent or mitigate the migration of contaminants and the associated risk. Numerous short- and long-term adverse impacts do exist for these alternatives, however. The most noteworthy are the permanent loss of wetlands and an increased potential for contaminant resuspension and migration during the dredging and disposal operations.

The use of a liner would both reduce the potential risk of leakage from the disposal site and increase the acceptability of this alternative. These advantages would be offset, however, by actual and potential adverse impacts associated with the temporary storage of additional contaminated sediments in shoreline areas (e.g., the cove on the western shore) and site dewatering. The placement of a sand blanket (for bearing support) and liner over the extensive disposal area (approximately 60 acres), in addition to the initial dewatering of this area, result in an estimated threefold increase in costs relative to the partially lined disposal area alternative ($79.5 million versus $27.8 million).

The use of an upland disposal site eliminates many of the critical environmental impacts of the other alternatives, but introduces many new environmental, public health, and community impacts. This alternative potentially involves the removal of the contaminated sediments to new and uncontaminated areas and communities that are not directly affected by the hot-spot areas. This not only severely reduces the overall acceptability of the option, but may introduce a more stringent interpretation of the regulations for waste generation, hauling, and disposal than that associated with "onsite", in-harbor disposal and control of the contaminated sediments.

Each of the remedial action alternatives (less the no-action alternative) developed in this study is considered to be technically feasible and responsive to the study objectives. The chemical behavior of PCBs is particularly compatible with the isolation and containment schemes proposed. PCBs do not appreciably solubilize in water; they are strongly adsorbed onto solid particles such as organic and silty sediments; and they undergo only limited volatization. Other alternatives may likewise achieve the study objectives with a variation in associated costs and impacts. Additional alternatives identified during the period of review and comment will be subsequently considered as to their pertinency and cost-effectiveness.

1.0 INTRODUCTION

1.1 Authorization For Study

The United States Environmental Protection Agency (EPA), under authority promulgated by the Comprehensive Environmental Response, Compensation, and Liability Act (i.e., the Superfund Act), assigned the New Bedford Site in Bristol County, Massachusetts to its National Priorities List of hazardous waste sites in July, 1981. This assignment qualified the site for monies and resources created by the Superfund Act. The New Bedford Site was so assigned because the widespread presence of polychlorinated biphenyls (PCBs) in the New Bedford Harbor and surrounding areas pose a threat to the public health, public welfare, and environment. The site has been designated by the Commonwealth of Massachusetts as its highest priority uncontrolled hazardous waste site.

Under EPA Work Assignment No. 28-1L43, issued on August 24, 1983, the Remedial Planning Office of NUS Corporation (NUS) was authorized to prepare a Work Plan for a Remedial Investigation and Feasibility Study for the New Bedford Site. The Work Plan (NUS, 1984), which was in large part based on the Remedial Action Master Plan (RAMP) for the New Bedford Site (Weston, 1983), provided a detailed scope of work, cost estimate, and schedule to satisfy the overall objectives of the Remedial Investigation and Feasibility Study. A critical element of the Work Plan is a fast-track Feasibility Study of remedial action alternatives for the highly-contaminated mudflats and sediments of the Acushnet River Estuary north of the Coggeshall Street Bridge. This fast-track study was requested by the EPA, and the Commonwealth of Massachusetts since extremely high levels of PCBs in these locations (i.e., the "hot spots") to pose an immediate risk to public health, public welfare, and the environment, and because contaminants are migrating from this area. On October 18, 1983, NUS received interim authorization to proceed with both the fast-track Feasibility Study and a related study of potential disposal sites for contaminated sediments that would be dredged from the Acushnet River Estuary under several of the potential remedial action alternatives.

1.2 Study Objectives

The objectives of the overall remedial action program for the PCB hot-spot areas of the Acushnet River Estuary are the following:

- To decrease the immediate risk to public health. The high levels of PCBs and possibly other contaminants in the hot-spot areas currently pose a potential public health threat due to the hazard assoicated with direct contact with the contaminated mudflats and sediments, uptake of PCBs through the ingestion of contaminated fish and shellfish, and respiratory inhalation of PCBs in the volatile and particulate forms.

- To decrease the impacts on aquatic and terrestrial organisms and resources within the upper harbor that have been impacted by high levels of the chemicals. The elevated levels and the impacts on public health and welfare associated with contaminated animal and plant communities will continue until the contaminants are removed from the food chain and plants.

- To decrease the potential for contaminant migration from the hot-spot areas to other less contaminated or uncontaminated areas. If left unremediated, the contaminants will spread until a larger portion of the aquatic community becomes unfit or unavailable for the food chain and ultimately for human consumption. The progressive movement of contaminated sediments and surface waters out of the upper estuary into New Bedford Harbor and Buzzards Bay also exacerbates water quality problems and related socioeconomic problems in these downstream water bodies.

The objective of the fast-track Feasibility Study is to evaluate potential alternatives in relation to engineering feasibility criteria, public health and environmental impacts, costs, and various other considerations, such as future risk, community acceptability, and impacts. No single alternative was found to be free of engineering constraints, environmental effects, and potential community impacts. Therefore, several alternatives to achieve hot-spot remediation, in relation to the imposed evaluation criteria, have been developed so that the EPA, other involved Federal agencies, the Commonwealth of Massachusetts, and the affected communities can properly assess the alternative actions.

1.2.1 Level of Clean-up to be Achieved

The level of clean-up to be achieved by any remedial action must be established prior to the development and evaluation of the remedial action alternatives. In the case of PCB-contaminated sediments, one potential target level is the value of 50 ppm specifically referenced in the Toxic Substances Control Act (TSCA). Any sediment containing greater than 50 ppm (dry weight) PCBs is classified as a PCB-contaminated waste that becomes subject to TSCA requirements (e.g., disposal by chemical waste landfilling or high temperature incineration).

Clean-up to a 50 ppm level would not satisfy all the study objectives, particularly in relation to an eventual lifting of the fishing ban in light of the FDA limit of 2 ppm in fish. This level would at least relieve the regulatory constraints of TSCA if any future dredging operations are proposed, and would serve to reduce the PCB loadings to downstream areas. A 50 ppm value is thus considered to be the least stringent target value for the current study.

The level of clean-up that would have to be achieved to satisfy (in the long-term) the FDA limit of 2 ppm in fish remains uncertain but is likely to be very small considering that PCBs bioaccumulate in aquatic organisms. For purposes of this study, an average value of 1 ppm is considered to be the lowest limit that can be practically achieved in the estuary. As such, the original intent of the fast-track Feasibility Study was to comparatively evaluate the cost-effectiveness of remediating the hot-spot areas to target levels of 1 ppm, 50 ppm, and an intermediate value of 10 ppm.

In trying to assess the lateral and vertical extent of sediments contaminated in excess of the three target levels, it became apparent that at least 80 percent of the study area contained sediment PCB concentrations in excess of 50 ppm (as discussed in Section 3.0). Further, the area with lesser values was downstream near the Coggeshall Street Bridge and appeared to be anomalous in relation to general contaminant location and migration patterns. Two reasons can be postulated for the possible underestimation of contaminant levels in this area. First, the frequency and lateral coverage of data collection efforts in this area are limited compared to other areas to the north. Second, since most samples were only taken from the top several centimeters of the sediments and the area immediately upstream of the bridge is a high sedimentation area, it is likely that the more contaminated sediments historically deposited in this area underlie the sampled depth.

What is important is that at least 80 percent and likely more of the study area would require "clean-up" even under the least stringent 50 ppm criterion. For this reason, it has been assumed in the fast-track Feasibility Study that sediments throughout the estuary above the Coggeshall Street Bridge will be removed or isolated under any remedial action. The additional level of effort and costs of extending any remedial action to areas with PCB concentrations that are in fact less than 50 ppm will be only a few percent relative to the total remedial action project. Such an error is within the overall error bars in the conceptualization and costing of alternatives. The final result is that a clean-up level of 1 ppm will be achieved in most areas since any isolation alternative will inherently isolate all contaminated sediments, and any removal alternative will operationally remove all sediments to a depth below the highly contaminated areas

1.3 Overview of Methodology

The fast-track Feasibility Study for the New Bedford Site was conducted using a multilevel screening and evaluation process. Two levels of technology screening were carried out prior to the development and evaluation of remedial action alternatives. This approach was followed in order to select only the most feasible and effective technologies for incorporation into the remedial action scenarios, thereby minimizing the number of potential alternatives to be considered in the detailed cost-effectiveness evaluation.

The objective of the initial screening of technologies was the elimination of all technologies that are either infeasible or inappropriate to the problem under study. According to the National Contingency Plan, only established technologies should be relied upon when feasible and cost-effective (NCP 300.61(c)(4)). A principal criterion for elimination was, therefore, that only proven technologies should be considered for the remediation of the hot-spot areas. The other principal criterion was that the technology be applicable to the specific conditions in the upper estuary. This, for example, would eliminate technologies that apply only to PCB-contaminated transformer oils and not PCB-contaminated sediments.

The technologies remaining after the initial screening then entered a secondary level of screening. The objective of this phase of the study was to compare and evaluate individual technologies within each technology grouping (e.g., dredging, treatment, etc.) in order to retain only the most feasible technology for each grouping. The criteria used to evaluate the technologies in the secondary screening were specific to each grouping, and included cost and effectiveness measures.

The potential remedial action alternatives were developed as various combinations of the remaining technologies. Although the number of potential combinations is large, most were eliminated since they did not satisfy the established minimum cost-effectiveness criteria. The selected alternatives then underwent a detailed cost-effectiveness analysis. The most cost-effective alternatives for the remediation of the hot-spot areas in the Acushnet River Estuary were subsequently identified and recommended, with due consideration given to the health risks and environmental impacts that would be eliminated or reduced by the remedial action and those that would be created or aggravated by the action.

1.4 Information Sources: Previous Studies

Because remediation of the hot-spot areas is urgent, the fast-track Feasibility Study was to be based on the extensive information available from previous engineering and scientific investigations and data collection efforts. In the progress of this study, however, some informational gaps were identified. Of particular note was a lack of documented information on the characteristics and engineering properties of the deeper sediments in the local study area. Additional sources of information were pursued (including individuals with local expertise), and a moderate degree of confidence now exists that the assumptions made in the conceptual development of the alternatives are consistent with actual field conditions. Additional field data collection programs will be necessary, however, prior to final design. The scope of these programs will depend on the selected remedial action and cannot be formulated at this time.

Literally scores of studies related to the New Bedford Site were reviewed during the course of this work. These range from particularly relevant investigations of potential remedial actions and data collection efforts to define the nature and extent of contamination, to more general studies of harbor development and regional resources. Although these studies did not focus on the hot-spot areas, most did provide some data or information used in the fast-track Feasibility Study. Three of the most pertinent of these studies are discussed below. Others are referenced as appropriate in subsequent sections of this report.

Two previous studies specifically addressed harbor contamination in relation to potential remedial actions. These are the Malcolm-Pirnie, Inc. study conducted for the Commonwealth of Massachusetts and a study by Geotechnical Engineers, Inc. for the New England Governors' Conference. Each of these studies focused on the removal of contaminated sediments by dredging.

The Malcolm-Pirnie study considered other alternatives but concluded that dredging is the only feasible remedial action. A number of dredging programs were developed around target levels of contaminant removal, including programs to reduce the environmental contamination in the harbor and to relieve existing constraints on dredging for harbor development and improvement. Considerable information was compiled on the technical aspects of dredging, including dredging techniques, available equipment, and costs. A general conclusion was that dredged sediments containing >50 ppm PCBs would require upland disposal, whereas sediments containing <50 ppm PCBs were assumed suitable for shoreline disposal. No in-depth study was performed, however, regarding the disposal of the contaminated dredged sediments. No consideration was given to the toxic metal contaminants.

The study by Geotechnical Engineers also addressed dredging techniques, the transportation of dredged material, and disposal options. Relevant case histories were discussed. No final recommendation for a dredging program for New Bedford Harbor was made, however, since it was concluded that dredging and transportation techniques are tied to uncertain disposal options. The report dismissed incineration and biodegradation as infeasible disposal options. The high concentrations of toxic metals were noted, but no special consideration was given to the metals in relation to dredging programs.

A major shortcoming of the use of these previous studies is that they summarily dismissed alternatives other than dredging as infeasible. Due to EPA policies and the requirements of the National Contingency Plan for remediating hazardous waste sites, other alternatives had to be developed and evaluated in this study. This is particularly important to the New Bedford Site, since disposal of the contaminated dredge materials remains an unresolved issue due to regulatory and environmental constraints. In the current study, other available technologies for remediating PCB pollution problems were assessed, and one of the remaining remedial action alternatives does not involve dredging. The dredging alternatives were independently assessed in this study in order to address specific performance standards set up in relation to multi-component remedial action scenarios.

Also noteworthy is the extensive information provided by Tibbetts Engineering Company of New Bedford from its previous engineering studies of the harbor. This information included boring logs from within the harbor, geotechnical testing data for sediment samples, bulkhead design parameters, and a bathymetric map. The informational gaps on sediment properties were, to some degree, satisfied by the Tibbetts data.

Numerous general references on PCBs and engineering issues were also utilized in the course of this study. Of particular note is a large collection of documents published by the Corps of Engineers as part of its ongoing research program on various aspects of dredging contaminated sediments. An Interagency Task Force, composed of representatives of involved Federal, State and local agencies, performed interim reviews of study methodologies and results, and provided input on regulatory and policy issues.

1.4.1 Chemical Data Base

The principal source of the chemical data used in this fast-track Feasibility Study is the data management system developed and managed by Metcalf and Eddy under a separate EPA contract. This data management system was used to catalogue existing data from numerous sources. The following discussion is based on a final report prepared by Metcalf and Eddy on the data management system (Metcalf and Eddy, 1983).

The chemical data base for the Acushnet River Estuary/New Bedford Harbor/Buzzards Bay system contains more than 5,000 individual data entries, *representing approximately* 3,700 PCB *analyses* and 1,400 analyses of other parameters, primarily heavy metals. The data base reflects the efforts of 21 data collecting agencies and 23 analytical labs over the past ten years. A reference list of these data sources is included in Appendix A. Each data entry includes the following information, where relevant and available:

- Sample identification (sample, station and lab numbers).

- The agency that performed the study.

- Sample type, in several levels of detail.

- Location of sample, and date and time of sample collection.

- The lab that performed the analysis, the date of analysis, and the analytical methods used.

- The parameter analyzed, measured concentration, units of measurement, detection limit, and solids content of the sample.

- Any additional information and comments.

More than 50 percent of the data entries represent analyses of estuarine sediments, and 4 percent are water column analyses from the estuary. An additional 26 percent of the data are analyses of aquatic biota. Thus, more than 75 percent of the existing data base comprises samples from the estuary/harbor/bay system, as opposed to land-based locations, such as upland landfills, previous disposal sites, industrial plants, and municipal facilities.

In order to ensure the quality of the data base, all of the data were screened by Metcalf and Eddy using criteria developed to evaluate the reliability of each measurement. Based on this evaluation, the data were divided into three categories: "reliable" data, or those for which the sample collection and analytical methods were documented and possess a reliability worthy of the fullest confidence; "incomplete" data, for which the documentation necessary to ascertain the reliability was unobtainable; and "unusable" data, which possessed collection and/or analytical deficiences that precluded their use. In cases where quality control documentation was not available to substantiate the analyses, the data was designated "reliable" only if the laboratory performing the analysis maintained state certification for the analysis of pesticides, herbicides and volatile organics (under Section 304(s) of the Federal Water Pollution Control Act); thus, proven procedures (40 CFR Part 136) were used. On the basis of this data evaluation, 91 percent of the data base was deemed reliable, 5 percent incomplete, and 4 percent unusable.

The utility of the data management system is not limited to a cataloguing of the existing data. A flexible, interactive capability has also been developed to perform statistical analyses of the data. This allows the development of concentration profiles throughout the estuary and harbor system, the identification of areas with insufficient data coverage, the computation of the volume of sediments above critical concentration levels, etc. During the course of this study, NUS personnel interacted directly with the Metcalf and Eddy staff in updating, modifying, and utilizing the data management system to satisfy the study needs.

2.0 PROJECT SETTING

2.1 Study Area

The study area for the fast-track Feasibility Study encompasses three geographical areas. The geographic focus is the hot-spot area itself, which for purposes of this study is considered to be the Acushnet River Estuary extending northward from the Coggeshall Street Bridge to the Tarkiln Hill Road Bridge (Figure 2-1). Of interest to the analysis of the problem and remedial action are those areas currently impacted by the presence of contaminants in the upper estuary. These areas include the remainder of New Bedford Harbor and Buzzards Bay, and the adjacent communities of New Bedford, Acushnet, and Fairhaven (Figure 2-2). The consideration of communities beyond these areas is limited to the analysis of potential disposal sites. The geographic limits of the siting study are approximately as shown in Figure 2-2.

2.2 Historical Setting

New Bedford Harbor, a tidal estuary at the mouth of the Acushnet River on the northwestern side of Buzzards Bay, is the waterway approach to the city of New Bedford and the towns of Fairhaven and Acushnet. New Bedford is located on the west side of the harbor and Fairhaven and Acushnet on the east side. Throughout the past, the communities have been linked to the sea. The first settlement in the area occurred about 1650, when a group of thirty-six dissenters from the Plymouth Colony purchased a tract of land that today encompasses New Bedford, Acushnet, Fairhaven, Dartmouth, and Westport. Although farming was the main economic activity, the area soon turned seaward. The development of whaling began in the 1760's, with shipbuilding activities as part of the industry. By 1775, Bedford Village was New England's second largest whaling port, surpassed only by Nantucket.

BASE MAP IS A PORTION OF THE U.S.G.S. NEW BEDFORD NORTH, MA QUADRANGLE (1979), 7.5 MINUTE SERIES, CONTOUR INTERVAL 10'.

LEGEND

HOT SPOT AREA

(AS DEFINED FOR THIS STUDY)

FIGURE 2-1

HOT SPOT AREA

NEW BEDFORD SITE, NEW BEDFORD, MA

SCALE: 1" = 2000'

NUS CORPORATION
A Halliburton Company

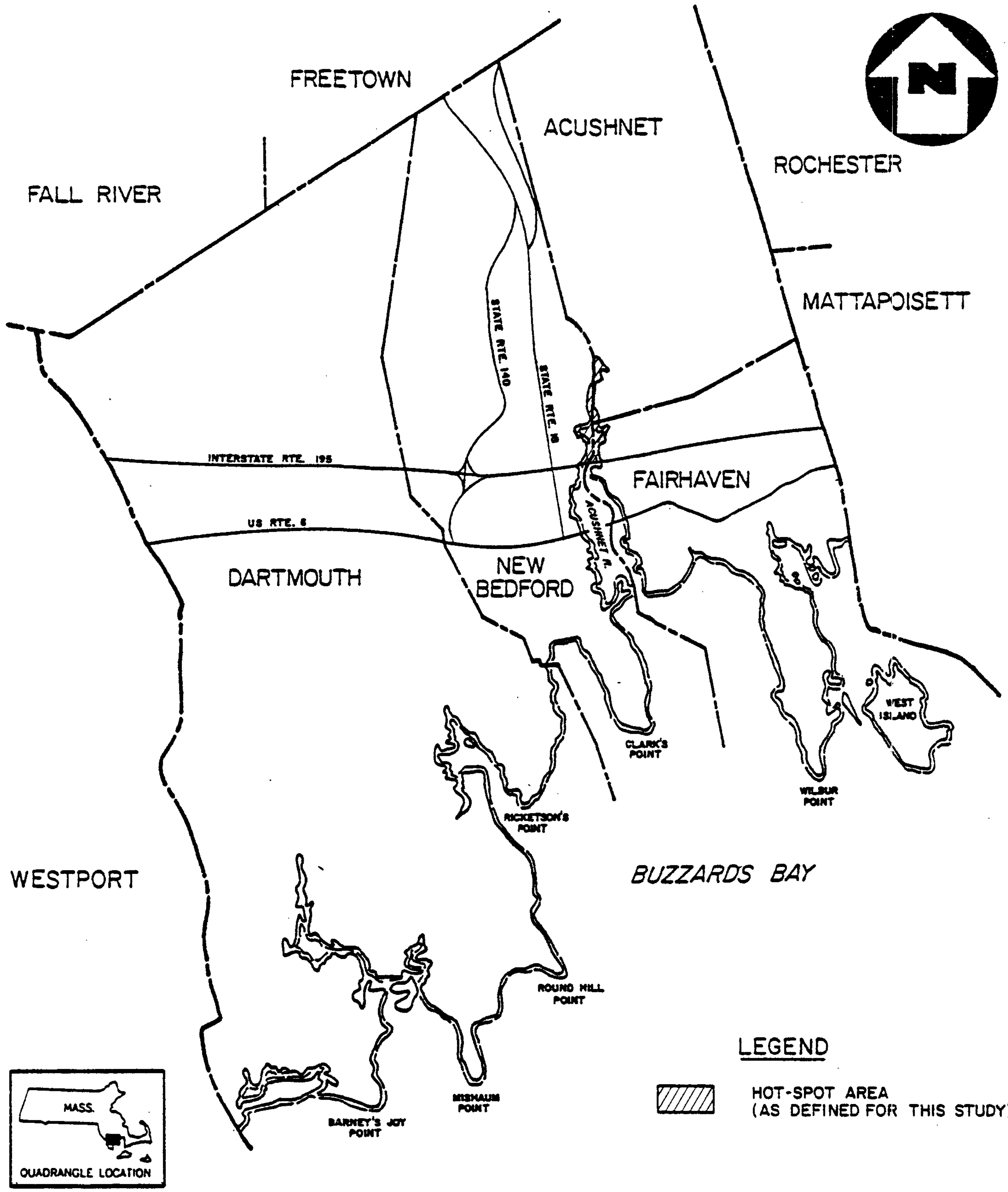

FIGURE 2-2

LIMITS OF STUDY AREA
NEW BEDFORD SITE, NEW BEDFORD, MA
SCALE: 1" = 2.2 MILES

NUS CORPORATION
A Halliburton Company

The settlements of Acushnet, Fairhaven, and Bedford Village were incorporated into the Town of Bedford in 1787. In 1812, Fairhaven and Acushnet separated and formed the Town of Fairhaven. The commercial and whaling industries continued their steady growth, and by 1830, New Bedford surpassed Nantucket as a whaling center and became the whaling capital of the world. During this time, ethnic diversity increased in the area, as Portuguese and other foreign seamen arrived to man the whaling ships.

Whaling stimulated the growth of satellite industries and other commercial activities. In 1846 two cotton textile mills were built; one of these was the Wamsutta Mill, which became world renowned. Oil was discovered in Pennsylvania in 1857 and with its discovery began the decline of the whaling industry, as an alternative source for petroleum was now available. Capital, accumulated during the years of whaling prosperity, was invested in the city's cotton textile industry. During the half century following the Civil War, twenty-six cotton textile mills were constructed along the shore of the New Bedford Harbor.

The textile industry focused on the production of fine cotton goods and became a world leader in these products toward the end of the nineteenth century. Until the 1930s, the city's economic prosperity was based on the textile industry. Shipbuilding, fishing, and marine-related services continued to be an important part of the economy throughout these years. The Great Depression dealt the textile industry a blow from which it never fully recovered. Government programs and the advent of World War II helped New Bedford recover from the effects of the depression, and since the end of World War II the city has attempted to broaden its economic base (New Bedford Planning Department, 1976).

Development of the fishing industry in the New Bedford area began in the 1930's. Today, the industry continues to flourish despite the contamination, since the commercial catch is from outside the impacted areas. New Bedford currently ranks first among the nation's ports in value of catch ($109.2 milion in 1983) and eighth in volume of fish landed (111.8 million pounds in 1983). Plans for expanding the New Bedford fleet and for developing diversified uses of the waterfront have been affected by the PCB problem, however, as will be discussed in Section 3.3.

In 1929, the first of two major electrical component manufacturers, Cornell-Dubilier Electronics, began operation in New Bedford. The second, Aerovox Industries, Inc., began operation in the 1930's. These industries are housed in old textile mill houses located on the banks of the Acushnet River Estuary, and both remain in business today. Their use of PCBs in the manufacture of electronic capacitors has brought a series of contamination problems to the area.

PCB contamination in the New Bedford area was first documented by both academic researchers and the Federal Government between the years 1974-1976. The EPA conducted a New England-wide PCB survey and found high levels of the chemical in various harbor locations. Testing revealed that Aerovox and Cornell-Dubilier were discharging wastewaters containing PCBs directly to the estuary/harbor/bay system. Indirect discharges also occured from these industries by combined sewer overflows, via the New Bedford municipal wastewater treatment facility, and from surface water runoff.

Also, toxic heavy metals such as copper, chromium, zinc, and lead were released by metals manufacturing and textile dyeing operations over the past 80 years. The disposal of these wastes by industries has led to environmental contamination of the estuary and harbor.

2.3 Socioeconomic Setting

A large portion of the Town of Acushnet lies outside of the immediate study area (Figure 2-2). Even the southern part of the town that does border the hot-spot area is almost totally isolated from direct access to the harbor by a large tidal marsh. For these reasons, this discussion of socioeconomic issues and the subsequent assessment of public welfare problems (Section 3.3) will focus only on the waterfront communities of New Bedford and Fairhaven.

New Bedford and Fairhaven are located in Bristol County in southeastern Massachusetts. The communities are about 56 miles from Boston, 208 miles from New York City, and 33 miles from Providence, Rhode Island. The City of New Bedford covers slightly less than 20 square miles, with approximately 18.9 square miles of land and 0.8 square miles of water comprising the total land area. Fairhaven covers almost 13 square miles, with about 12.2 square miles of land and 0.3 square miles of water (Massachusetts Department of Commerce and Development, 1983 and 1984).

New Bedford was incorporated as a city in 1847. Census statistics dating from 1920 show a decline in the number of people living in the city. In 1920 there were 121,217 residents, but as a result of steady declines throughout the following decades, the 1980 population stood at only 98,478. Between 1970 and 1980, New Bedford's population decreased by 3,299, or 3.2 percent. During that decade, there was an estimated excess of births over deaths of 2,303 and an estimated out-migration of 5,602 (Massachusetts Department of Commerce and Development, 1983).

Fairhaven was settled in 1653 and was originally known as Sconticut, the name of the Indian tribe living there. Until incorporation as a city in 1812, Fairhaven was part of New Bedford. Census statistics since 1920 show that the 1980 population of 15,759 is more than twice the size of the 1920 population, although fluctuations have occurred over the decades. Fairhaven's population decreased between 1970 and 1980 by 573, or 3.5 percent. There was an estimated excess of births over deaths of 107 and an estimated out-migration of 680 during that decade (Massachusetts Department of Commerce and Development, 1984).

Today, New Bedford is a major fishing port that ranks first nationally in value of catch and is considered to be the unofficial scallop port of the world (Bristol County Development Council, Inc., 1984). This ranking is based primarily on landings from the offshore fishery in the Northwest Atlantic. Instead of a fleet of whaling ships, there is a fleet of trawlers, draggers, scallopers, and lobster boats in the harbor, and seafood processing plants are located near the waterfront. On the other side of the harbor, the Fairhaven waterfront area serves as a repairs complex for the fishing fleet. Marine specialists are available for the fleet and for cruising boats. Shipping that occurs in the harbor includes receipts of petroleum, lumber, fish, and textiles; exports are flour, general cargo, and frozen fish (New Bedford Planning Department, 1976).

The size of the fishing fleet in 1983 was estimated to be 200 vessels, an increase of approximately 50 new vessels since 1976, and a 1981 survey of marina operators indicated that up to 130 motorboats or yachts could be moored at marinas in the New Bedford Harbor. The total number of direct and indirect jobs provided by the fishing industry was estimated to be 2,736 in the New Bedford area (Southeastern Regional Planning and Economic Development District, 1983b; Economics Research Associates, 1981).

With a 1980 population of approximately 98,500, New Bedford was an employment center for about 47,200 persons in 1982. The largest employment sectors include manufacturing (45 percent), services (16 percent), government (12 percent), and retail trade (12 percent). The agriculture and fisheries sectors employ 3 percent of the workforce, with most of these workers employed in fishing (Massachusetts Department of Commerce and Development, 1983). Many jobs included in the manufacturing, services, and retail trade sectors, however, are related to the fishing industry.

Fairhaven, with a 1980 population of about 15,760, was the place of employment for approximately 3,860 workers in 1982. Retail trade was the largest employment sector (34 percent), with services (15 percent), government (12 percent), and fisheries (11 percent) employing large segments of the workforce. Fairhaven functions as both a residential suburb of New Bedford and a summer resort on Buzzards Bay, in addition to being a workplace (Massachusetts Department of Commerce and Development, 1984).

Major employers in New Bedford include manufacturers of apparel, textiles, rubber products, and electronics. Marine-related industries in New Bedford have diversified in the past decade from the manufacture of ropes and fish nets to modern fish filleting plants and marine electronics. Industrial land is scattered throughout the city, with a concentration of mills along the waterfront and near the airport. An industrial park has been developed off Route 140 in the northern part of the city. Two large waterfront areas (North and South Terminals) were prepared for development through urban renewal as sites for future industrial activity (Southeastern Regional Planning and Economic Development District, 1976). Today, the South Terminal has fish processing plants at dockside, while there are several acres of land available for development at the North Terminal.

The major employers in Fairhaven include firms that perform ship repairs and conversion, and manufacturers of winches and marine machinery, sewing threads, loom crankshafts, tires and inner tubes (Southeastern Regional Planning and Economic Development District, 1982a). Although space for the expansion of marine-related industry along the Fairhaven waterfront is limited, industrial development in the northern half of the town has been initiated with the construction of newspaper and telephone company buildings and a few warehousing facilities (Southeastern Regional Planning and Economic Development District, 1976).

The New Bedford Labor Market Area includes New Bedford, Fairhaven, and seven other towns and cities in Bristol and Plymouth Counties. One characteristic of the entire New Bedford Labor Market Area is high unemployment rates. In New Bedford the 1980 unemployment rate was 8.6 percent. The 1982 rate was 14.3 percent, which was higher than the labor market area rate of 12.4 and the state unemployment rate of 8.0 percent. Seasonal unemployment may be a contributing factor to New Bedford area unemployment. A regional review of the district's economy concludes that the southeastern Massachusetts region has several positive attributes that should encourage development and that "reindustrialization" is occurring. This redevelopment is the result of investment in new industries, diversification, and more emphasis on non-manufacturing growth (Southeastern Regional Planning and Economic Development District, 1983a).

2.4 Hydrologic Setting

2.4.1 Climate

The climate of coastal areas in Massachusetts can be described as highly variable. The changeability of the weather from day to day is the result of three factors--the latitude, which is in the area of predominant west to east air flow, but which encompasses areas of north-south air flow from the polar regions and tropics; the location on a major storm track, which reinforces the effects of latitude and contributes to an even distribution of precipitation throughout the year; and the ocean, which moderates the fluctuations experienced inland.

The average annual precipitation is 39.8 inches, with a mean monthly maximum of 4.25 inches in July. The area receives an annual average snowfall of 32.5 inches. Mean monthly temperatures range from 31.0°F in February to 72.2°F in July. The first frost typically occurs in the second week of November, and the last frost usually occurs in early April.

2.4.2 Surface Water

The principal water bodies in the study area include the Acushnet River Estuary, New Bedford Harbor, and Buzzards Bay. The mouth of the Acushnet River, a tidal estuary forming New Bedford Harbor, discharges into the northwestern side of Buzzards Bay. The area of the estuarine portion of the river above the Coggeshall Street Bridge is approximately 202 acres at mean high water (mhw). The width averages 850 to 950 feet along the length of the river channel with a minimum of 300 feet at the head and a maximum of 2200 feet downstream at the cove on the western shore. The greatest depths are associated with the main channel, which trends northward through the center of the basin. The main channel has a mean low water (mlw) depth of 18 feet at the constricted opening of the Coggeshall Street Bridge. The depth quickly decreases to 6 feet and then to 2 feet at the head of the estuary. Depths become rapidly shallow both east and west of the main channel, as water depths are commonly less than 3 feet mlw in these areas.

The Acushnet River above the Coggeshall Street Bridge experiences diurnal tides with a mean tidal range of 3.8 feet and a maximum inequality between successive high tides of 1.2 feet (NOAA, 1981). The National Geodetic Vertical Datum (msl) at this locality is equal to a local tide level of 1.6 feet above mlw. The time period is 6.5 hours ebb or flood tide, for a total cycle time of 13 hours. The tidal prism of the Acushnet River above the Coggeshall Street Bridge is estimated to be 65,664,000 cubic feet for the complete flood/ebb tidal cycle. The tidal prism is the volume of water which flows into and out of a basin in the course of a complete flood/ebb tidal cycle. The calculated mlw volume of the estuary is estimated to be 25,524,000 cubic feet. Using these two volumes, the flushing time for the basin is estimated to be 1.4 tidal cycles, or approximately 18.2 hours. Flushing is the average time, in complete tidal cycles, for a complete exchange of a given volume of water within a basin.

The Acushnet River has an estimated mean annual freshwater discharge of 30 cfs. During a 6.5-hour ebb or flood tide this would amount to an average freshwater input to the estuary of 700,000 cubic feet, which is only one percent of the average tidal input (tidal prism). River flows will vary throughout the year. During dry periods, days in which no flow occurs are not uncommon. The predicted 7-day, 10-year low flow is less than 0.5 cfs. The 100-year storm flood is estimated at 1,350 cfs. Other estimated storms include 50-year, 800 cfs; 25-year, 725 cfs; and the storm flow for the 10-year recurrence interval, 600 cfs. Water surface elevations of the Acushnet River Estuary above the Coggeshall Street Bridge are summarized in Table 2-1. Note that the clearance elevation at the bridge is approximately 8.7 feet msl.

The sedimentation rate in the area has been estimated to range between 1.7-4 centimeters/year (cm/yr) since the construction of the hurricane barrier, an increase from the estimated rate of 0.2-1 cm/yr prior to 1966.

TABLE 2-1

WATER SURFACE ELEVATIONS
ACUSHNET RIVER ESTUARY

Item	Water Surface Elevation *(feet above msl)*
100-year Flood, 1,350 cfs	
Above Saw Mill Dam	12
Below Saw Mill Dam	7
Acushnet River Estuary	6
Tide	
Mean spring tide	3.1
Mean high tide (mhw)	2.2
Mean low tide (mlw)	-1.6

The overall flow and circulation patterns in the Inner Harbor (i.e., inside the hurricane barrier) are primarily forced by conditions in the Outer Harbor, which in turn are driven by conditions in Buzzards Bay. Tidal currents in the harbor approaches are generally less than 1 foot per second (fps), while currents in the harbor entrance increase to about 4 fps. The existing data indicate that flows are onshore along the bottom of the harbor and offshore in the upper water column, resulting in the picture of New Bedford Harbor as a "leaky sink" for pollutants (Summerhayes, WHOI, 1977). The net exchange of flows and sediments during storm conditions is unknown and will be investigated in later studies.

Buzzards Bay is a semi-enclosed sea with no major tributaries; however, numerous small streams provide local freshwater sources along the northern shore of the bay. The overall circulation in Buzzards Bay outside of New Bedford Harbor is not well documented, but a net counter-clockwise circulation pattern is expected. There are many indications that the flow out of New Bedford Harbor hugs the coast along the northwest shore of Buzzards Bay and flows southerly out of Buzzards Bay. Existing data show that sediment resuspension occurs around the Bay and in the Outer Harbor from the action of surface waves, since the tidal, low frequency, and mean flow field cannot generate sufficient stress to resuspend much sediment. Wave action sufficient to resuspend sediment in shallow water can be generated by local sea breezes in the summer and early fall. Over most of the Outer Harbor and Buzzards Bay, only storm waves can resuspend the sediment (Battelle, 1984).

2.4.3 Groundwater

The study area is located in the Coastal Lowlands Physiographic Province of New England. The present topography is a product of physical and chemical erosion and then subsequent glacial erosion and deposition. The area is underlain by Proterozoic Eon (older than 600 million years) plutonic, intrusive, and metamorphic rocks. The rocks are moderately deformed and highly faulted. Faulting causes weaker zones in the bedrock to erode, and in many cases, watercourses reflect these areas where water flows along the path of least resistance. The geomorphic features in the region of Buzzards Bay indicate a north-south lineation in the underlying bedrock. Examples of these features include the Acushnet River, New Bedford Harbor, and the intervening highlands. Figure 2-3 shows the approximate elevation of the bedrock surface in the vicinity of the study area. It is observed that the harbor is located in a bedrock valley.

Surficial geology in the region is a result of glacial activity. Most of the urban New Bedford and Acushnet/Fairhaven area is covered by drumlin and ground moraine composed of basal till. The till contains mostly silt, sand, and boulders. The areas along the Acushnet River are covered by both kame deltas and outwash deposits. North of the Acushnet area, kame deltas, consisting of gravels, sands, silts, and clays formed in temporary glacial lakes. The kame deposits generally overlie till. The river banks in New Bedford and Fairhaven consist primarily of outwash deposits of fine to coarse gravel.

Marsh areas are underlain by tidal peat deposits that consist of organic silt, silt, and sand. These organic deposits generally overlie the glacially deposited soils. Three groundwater zones can be identified in such areas, including groundwater flow in the bedrock, a water table and flow through the unconsolidated deposits, and a perched groundwater system that overlies the relatively impermeable, confining peat layers. Groundwater flow patterns in the bedrock are determined by the direction and extent of fracture patterns and are thus difficult to predict. It is probable that bedrock fractures extend to the harbor and thus the groundwater system in the bedrock may be hydraulically connected to harbor waters.

The extent of groundwater usage from the bedrock in the vicinity of the harbor is unknown but is not believed to be significant. Since the bedrock aquifer is overlain by tens of feet of unconsolidated deposits within the harbor, it is likely that PCBs and metals would be immobilized prior to reaching the bedrock zone.

The water table is expected to be within 10 feet of the surface in the low-lying areas surrounding the harbor. The depth of the water table is highly dependent on the annual hydrologic cycle, due to seasonal differences in the rate of groundwater

LEGEND

——0—— BEDROCK SURFACE ELEVATION CONTOUR

NOTE

CONTOURS TAKEN FROM AN UNPUBLISHED MAP BY J.R. WILLIAMS, U.S.G.S., 1974.

BASE MAP IS A PORTION OF THE U.S.G.S. NEW BEDFORD NORTH, MA QUADRANGLE (1979), 7.5 MINUTE SERIES. CONTOUR INTERVAL 10'.

FIGURE 2-3

APPROXIMATE BEDROCK SURFACE ELEVATIONS

NEW BEDFORD SITE, NEW BEDFORD, MA

SCALE: 1" = 2000'

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recharge and the relatively constant discharge. The largest groundwater recharge occurs during late winter or early spring, usually in March and April, as a result of precipitation and snowmelt. The water levels are lowest during late spring and early fall because of high evapotranspiration.

In the study area, groundwater and surface water flow are hydraulically connected. Since watertable elevations generally reflect patterns of surface topography, the regional groundwater flow direction is toward the harbor from both the east and west. However, during dry periods when water table elevations have declined, the harbor can recharge the groundwater through permeable bottoms. In addition, a "sloshing" effect can be created in the nearshore groundwater zones from tidal fluctuations. During high tide, a negatively sloping gradient is established in an inland direction. At low tide, the gradient reverses direction with flow toward the harbor. A monitoring well study at the Aerovox site (GHR, 1983) found that these tidal effects were barely distinguishable at a well located 300 feet from the river. It is unlikely that any groundwater recharge from the harbor penetrates more than 1000 feet east or west of the shoreline since any reversed gradient would not exceed the general regional gradient toward the harbor.

The perched water table is likely to be in areas underlain by a peat layer or other relatively impermeable material. The saturated thickness of the perched system depends on both the elevation of the peat layer and the tidal fluctuations. The same tidal effects with flow reversal have been observed in such perched groundwater zones (GHR, 1983).

The migration of PCBs and metals into the shallow groundwater zone during periods of flow reversal is not expected to be significant because (1) the contaminants are relatively immobile in the anoxic harbor sediments; and (2) the net component of the cyclic flow is toward the harbor. No water quality data are available for wells in the immediate vicinity of the estuary, with the exception of the Aerovox wells. These wells indicated PCB contamination, with readings of over 200 ppb in unfiltered samples from the perched system and about 150 ppb in unfiltered samples from the deeper, unconsolidated groundwater zone. Because of the potential storage, spillage, and disposal of PCBs on the Aerovox Site over an appropriate 40-year period, and the extreme hot-spots in the estuary immediately off the Aerovox property, these observed levels of PCB contamination should not be considered as representative of the overall groundwater quality in the area.

Groundwater withdrawn from outwash deposits along the Acushnet River Estuary would be saline. Groundwater in these deposits is not, therefore, the source of local water supplies. The New Bedford municipal water system serves New Bedford, Acushnet, and parts of Fairhaven with treated water from a surface water source.

2.5 Environmental Setting

2.5.1 Terrestrial Biota

New Bedford and the surrounding towns of Acushnet and Fairhaven exhibit a wide variety of both upland and wetland vegetation. Most of the naturally-vegetated communities occur north of I-195 and west of Route 40. The primary areas of concern in the estuary area are the wetlands along the river banks. Wetland communities can be classified as wooded swamps, shrub swamps, freshwater marshes, or saltwater marshes. Marshes such as those along the eastern side of the river in undeveloped areas are dominated by emergent vegetation.

Wetlands are regulated by both the State and Federal government. Executive Order 11990 (May 24, 1977) requires Federal agencies to avoid adversely impacting wetlands wherever possible, to minimize wetland destruction, and to preserve the values of wetlands. The Massachusetts Wetlands Protection Act (1974) prohibits activities that alter wetlands and areas within 100 feet of wetlands without the prior approval of the local Conservation Commission.

Although much of the New Bedford shoreline is developed, there is likely to be a wide diversity of small mammals using the shoreline corridor and nearby residential areas. The cove on the western shore of the hot-spot area and the areas near Acushnet and Fairhaven are thought to be breeding and feeding grounds for mammals, birds, amphibians, and reptiles. Mammals such as deer, raccoon, opossum, striped skunk, eastern cottontail, and meadow and redback voles are likely to use these wetlands. Swamps and wetlands are also likely to support populations of flycatchers, woodpeckers, warblers, wood thrushes, vireos, nuthatches, red-tail hawks, and owls. Marshes may also provide habitat for red-winged blackbirds, swamp sparrows, Virginia and sora rails, bitterns, and ring-necked pheasants. Green frogs, pickerel frogs, spring peepers, and eastern garter snakes are common marsh inhabitants in Massachusetts. Gulls and other fish-eating birds are present along the river. No rare, endangered, or threatened species are known to exist in the project area.

2.5.2 Aquatic Biota

Both freshwater and marine ecosystems are present in the study area. However, the marine ecosystem will be affected by remedial actions taken in the Acushnet River. The estuary and harbor are dominated by demersal fish such as American eel, winter flounder, scup, summer flounder, windowpane flounder, and tautog. There are few benthic macrofauna in the hot-spot areas north of the Coggeshall Street Bridge. Invertebrate demersal and epibenthic fauna found downstream in New Bedford Harbor and Buzzards Bay include lobsters, spider crabs, rock crabs, soft shell clams, quahogs, mussels, oysters, and limpets.

Benthic macroinvertebrates are secondary consumers of detritus, plankton, and other invertebrates, and are consumed in turn by fish and shellfish. It is this food chain, with fish and humans at the top, that bioconcentrates PCBs. Species expected to dominate in the Acushnet River Estuary include aquatic worms, flies, midges, snails, sow bugs, and water mites. These species are classified as either facultative (tolerant of organic contamination) or tolerant (able to thrive under grossly contaminated conditions), and are not indicative of a healthy aquatic environment.

Phytoplankton and zooplankton have not been characterized for this area.

2.5.3 Noise

Noise generators in the New Bedford area include traffic, industries, boats, and natural features of the coastal area, such as wind and surf. Noise generated by the nearby industrial operations can be expected near and around the harbor. This noise can be primarily attributed to transportation-related activities. No adverse impacts result from the existing noise conditions in the area.

2.5.4 Air Quality

New Bedford is located in an area that is designated as "attainment" with respect to the National Ambient Air Quality Standards for total suspended particulates, carbon monoxide, sulfur dioxide, and nitrogen dioxide. The area's "non-attainment" for photochemical oxidants is a statewide problem, due generally to activities throughout the northeasten United States rather than to local sources.

2.6 Subsurface Conditions

2.6.1 Sources of Existing Information

Conclusions on the subsurface conditions of the Acushnet River Estuary are based on six test borings performed in the location of the Coggeshall Street Bridge embankments and five test borings performed in and near the cove on the western shore of the estuary. It is recommended that prior to the design and implementation of any remedial action alternative that additional subsurface information be obtained throughout the upper harbor area.

2.6.2 Subsurface Characteristics

In general, the soil profile developed from existing information consists of recent alluvial sediments underlain by alluvial glacial outwash sand. The bedrock consists of granite, schist, and gneiss. The primary source of the recent harbor sediments is most likely from the outflow of the Acushnet River. Following construction of both the Coggeshall Street Bridge and the hurricane barrier, the amount of sedimentation has greatly increased. Based on the test boring information and visual observations of the shoreline, the thickness of the sediments most likely increases with distance from the shoreline. Thickness of the sediment layer varies between 0 and 30 feet. The sediments have been identified as black organic silt and silty sands by visual classification, and most likely exist in a very loose to loose condition due to natural deposition from the Acushnet River.

The sand encountered below the sediment ranges in thickness from about 10 to 25 feet. The sand is a combination of glacial outwash and alluvium deposits from the Acushnet River. The upper layer of the sand appears to contain smaller silt-size particles, with larger particles such as gravel and pebbles contained in the lower sand layers. Information obtained from the test borings indicates that the sand layer ranges in density from medium dense to very dense.

Published and unpublished geological data for the New Bedford, Massachusetts area indicates that bedrock is encountered below the sand layer at elevations from approximately -25 to -75 feet msl. Test borings in the immediate area were not advanced into the bedrock.

Additional subsurface investigations, including test borings and test pits, are recommended to provide the following engineering data and properties:

- Unified Soil Classification System identification of the soils encountered
- Water contents
- In-place densities
- Laboratory permeabilities

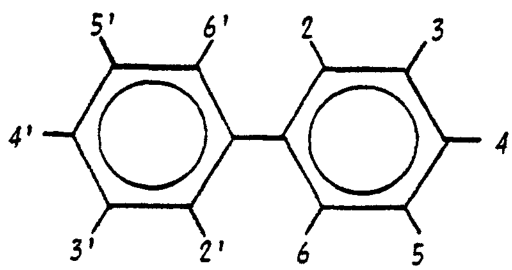
Additional strength characteristics can also be estimated through such tests as quick-drained direct shear tests and consolidated undrained triaxial tests. The triaxial test may be useful for settlement estimates to be made for the compressible organic silt layer.

3.0 CURRENT PROBLEM ASSESSMENT

In this section, the current problems associated with the hot-spot areas are identified and assessed in terms of the impacts on the environment, public health, and public welfare. There are two groups of problems, those directly caused by the hot-spot areas (e.g., public health risks posed by the highly contaminated mudflat areas) and those indirectly related to the hot-spot areas as a result of the continued movement of contaminants from the upper estuary to the downstream harbor and Buzzards Bay (e.g., the economic impacts of the closure of the outer harbor areas to the taking of lobster). Prior to addressing these problems, however, a description of PCBs is provided. PCBs exhibit relatively unique physical and chemical properties, and the description will put both the problems and the subsequently developed remedial action alternatives in the proper perspective. The toxic heavy metals are also briefly discussed.

3.1 Description of Contaminants

PCBs belong to a broad family of organic chemicals known as chlorinated hydrocarbons. PCBs are produced by attaching chlorine molecules to a biphenyl molecule. The biphenyl molecule consists of two benzene rings and has a total of ten sites where chlorine atoms can be substituted for hydrogen atoms. The general chemical structure is shown below:



Researchers first synthesized PCBs in 1881. They were commercially marketed in the United States during the years 1929 to 1977 by the Monsanto Corporation of St. Louis, Missouri, the United States' only industrial producer of PCBs. PCB blends were marketed under the trade name "Aroclor". Chemically, 209 different PCB molecules, or isomers, are possible. Each Aroclor is composed of a complicated blend of these isomers. Only about ten Aroclors were widely marketed in the United States. During the approximately fifty years of manufacture, it is reported that 1.4 billion pounds of PCBs were produced in the United States.

The industrial use of PCBs principally resulted from their chemical and thermal stability. The electrical industry took advantage of the relatively inert chemical behavior of PCBs and their excellent dielectric properties by utilizing PCBs in electrical capacitors, transformers, heat transfer systems, and hydraulic systems. PCBs are also fire resistant and have been used as flame retardants in a variety of products. Another use is as an additive to varnishes, waxes, sealants, glues, hydraulic fluids, lubricants, adhesives, and pesticides.

In New Bedford, PCBs have been used by Aerovox Industries, Inc. and Cornell-Dubilier Electronics, Inc. in the production of electronic capacitors. The usage of PCBs by New Bedford's industrial concerns was as high as about two million pounds per year during the years 1973, 1974, and 1975. Aroclor 1242 was the primary PCB used in New Bedford until 1971, when Aroclor 1016 became available for use in the manufacture of electronic capacitors. Aerovox and Cornell-Dubilier also used lesser quantities of two other Aroclors, 1254 and 1232. All use of PCBs in manufacturing in New Bedford stopped by 1978.

PCBs are regulated by the Toxic Substances Control Act (TSCA). In 1976, the EPA was given regulatory control of PCBs and other toxic substances, and on May 31, 1979, promulgated a rule that prohibits the manufacture, processing, distribution in commerce, and use of PCBs. The rule, however, generally excluded materials containing PCBs in concentrations under 50 parts per million (ppm) and the use of PCBs in totally enclosed systems.

PCBs generally maintain their thermal and chemical stability when exposed to water or natural environmental conditions. They do not appreciably react with or solubilize in acids, alkalis, or water. On the other hand, PCBs can be readily soluble in a variety of organic solvents such as benzene, hydrocarbon oils, and certain alcohols.

PCBs are denser than water, and are strongly adsorbed onto suspended solids in an aquatic environment. As a result, PCBs are usually found at much higher concentrations in sediments than in the water column. A critical aspect of remedial action is therefore directed toward the control of sediment dispersal and transport, since PCBs will be concomitantly moved with the sediments to other locations and would be more susceptible to resolubilization where equilibrium conditions with the water have not been established. These same properties decrease the risk of acute or catastrophic releases of PCBs from engineered, controlled disposal sites.

A risk posed by PCBs bound in the sediments is their availability to the aquatic food chain. Because PCBs are persistent, stable chemicals, they tend to bioaccumulate in organisms as they are passed up through the trophic levels of the food chain, ultimately reaching fish and man. Through bioaccumulation, even low levels of PCB exposure in an uncontrolled environment can have serious environmental and public health consequences.

PCBs undergo limited volatilization under certain environmental conditions, and can also be released to the atmosphere adsorbed onto airborne particulates. These processes introduce an additional route of environmental exposure that can be controlled by proper containment of the contaminated sediments.

In addition to high PCB levels in the estuary and harbor sediments, data indicate that the sediments also contain significant concentrations of heavy metals resulting from industrial discharges. The principal metal contaminants are copper, chromium, lead, and zinc, although lower concentrations of other metals (e.g., cadmium) may pose a greater public health risk. Under existing conditions in the estuary and harbor, the metals are not significantly mobile. The anoxic, saline environment of the sediments favors the formation of insoluble metal sulfides. The affinity of the metals for adsorption onto the silty sediments also contributes to their immobilization.

The development of remedial actions must consider the potential for resolubilization of the metals. For example, long-term exposure of the metals to an oxidizing environment would oxidize the sulfides and release the metals. This would occur if oxygenated waters are brought into contact with the sediments for a period of time or if the sediments are allowed to dry in air (e.g., in an upland landfill).

3.2 Environmental Contamination

PCB contamination has been found in several environmental media in the Acushnet River Estuary. Contaminants have been found in the air, water, sediment, and biota. The following sections summarize the environmental concentrations and trends of the contaminants found to date. Contaminant levels in the air, biota, water, and sediment of the estuary will be stressed, since this Feasibility Study addresses this particular factor. However, the migration of PCBs into New Bedford Harbor will be discussed, since the alternatives included in this study will impact on the occurrence and movement of contaminated sediments.

This environmental contamination summary is a compilation of all known data that are stored in the data management system. The data were obtained from separate sampling programs conducted over several years. The method of sampling and type of sample also varied in these programs and may have some impact on data comparison. However, the overall utility of the data for purposes of this assessment is not impaired. The purpose of this section, therefore, is to explain the present extent and character of the estuary contamination.

3.2.1 Air Contamination

GCA Corporation performed the most recent air monitoring program in the area over a period of 10 days between August 31, 1982 and September 9, 1982. Air monitoring was a concern because PCBs can volatilize or be adsorbed on respirable particulate matter, transported by prevailing winds, and deposited on land or water as a particulate or vapor (GCA, 1984). High volume air samplers were placed at each of 21 preselected sites in New Bedford, Acushnet, Dartmouth, and Fairhaven. Sampling locations were determined based on historical meteorological data which indicated seasonal prevailing winds emanating from the southwest.

The high volume air sampler collected particulates on a polyurethane filter and volatilized PCBs and related volatile organics on two polyurethane foam cartridges located downstream of the filter. The foam cartridge and filter extracts were analyzed separately. In all cases the filter samples resulted in non-detectable observations. These results are consistent with reported behavior of PCBs over long transport distances in ambient air, namely that they are generally partitioned in the vapor phase in ambient air and are not typically associated with airborne particulate matter. This may also be a characteristic associated with the sampling method, i.e., the majority of PCB isomers are transferred to the foam cartridges from the filter under the conditions of high volume sampling (GCA, 1984).

Extracts of the particulates and adsorbed volatiles were analyzed for PCBs and related organics, trace metals, and particulate concentrations in ambient air. These samples were taken from background sites, a number of suspected PCB emission sources, and previously uncharacterized areas. Air samples taken at background stations in New Bedford had PCB concentrations which did not differ significantly from values typically found in other North American urban centers.

Five air monitors were installed near the Acushnet River Estuary. Two were generally in the upwind direction (Burt School and Brooklawn Park) and three were placed in the anticipated downwind vectors. The latter included two samplers at

C&W Welding and one at the Acushnet Nursing Home situated to the north and northeast, respectively. Concentrations of total PCBs in the upwind samplers were within regional background values of approximately 10 nanograms per cubic meter (ng/m^3). However, the three downwind samplers had significantly higher PCB values. The C&W Welding monitors had PCB average concentrations of 93 and 76 ng/m^3 for Aroclor 1242/1016. The average Aroclor 1254 value was only 4.5 ng/m^3. At the Acushnet Nursing Home, the PCB monitor had an average Aroclor 1242/1016 concentration of 66 ng/m^3 and an Aroclor 1254 concentration of 3.4 ng/m^3. Comparing 1978 levels of 268 to 310 ng/m^3 downwind of the site, it is indicated that total PCB concentrations in the vicinity of the estuary have declined in the past five years. While the overall PCB concentrations in the vicinity of the site have diminished, the contaminated portions of the Acushnet River represent a long term, low level source of PCBs to the ambient atmosphere.

Trace metals were sampled at the C&W Welding samplers. Aluminum, calcium, lead, iron, silicon, magnesuim, zinc, and sodium were present in the highest concentrations (0.158 $\mu g/m^3$ to 66.0 $\mu g/m^3$). The remainder of the trace metals were detected in concentrations less than 0.144 $\mu g/m^3$.

3.2.2 Aquatic Biota

The aquatic community of the Acushnet River Estuary and the overall harbor system has been degraded by PCB and metal contamination. In September, 1979, the Commonwealth of Massachusetts closed the estuary to all fishing due to the PCB contamination.

Analytical results of finfish tissue samples are summarized in Table 3-1. The median PCB concentrations for numerous species of fish and shellfish are well above the recently-redefined Federal Drug Administration (FDA) action level of 2 ppm (lowered from 5 ppm). The action level is the PCB concentration in the edible portion of fish considered safe for human consumption. Eels seem to be the most

TABLE 3-1

PCB CONCENTRATIONS IN NEW BEDFORD AREA FINFISHES
(1976-1980)

Species	Median (ppm)	Mean (ppm)	High (ppm)	Low (ppm)	No. Sampled
American eel	24	131	730	11	32
Cunner	38	38	57	20	2
Summer flounder	7.4	9.3	22	0.2	10
Window pane	5.5	8.8	14.3	3.1	30
Winter flounder	6.8	6.4	22	0	44
Silver hake	3.5	3.5	6.4	0.7	2
Scup	2.3	2.1	11.4	0	50
Bluefish	0.3	2.1	16.5	0.2	11
Tautog	0.9	1.7	11.0	0.1	17
Striped bass	0.9	1.2	3.0	0.1	8
Fourspot flounder	0.8	0.8	--	--	1
Butterfish	0.5	0.5	0.9	LT 0.1	4
Black sea bass	0.4	0.4	--	--	1
Dogfish	0.2	0.2	--	--	1
Red hake	LT 0.1	LT 0.1	--	--	1

LT = less than
ppm = parts per million

Source: Massachusetts Coastal Zone Management, June 1982, PCB Pollution in the New Bedford, Massachusetts Area: A Status Report.

heavily contaminated species in the harbor. All samples collected to date had PCB concentrations exceeding 11 ppm with a mean value of 131 ppm (32 samples), and several eel samples exceeded 500 ppm. Lobsters were also found to be heavily contaminated. Of 183 lobsters sampled between 1976 and 1980, both the median PCB concentration of 4.9 ppm and the mean concentration of 8.7 ppm exceed the FDA action level. The maximum concentrations found in lobsters was 84 ppm.

Although no commercial fishing takes place in the area of concern, a number of species (bluefish, scup, striped bass, and Atlantic mackerel) may be taken by sport fishermen in the harbor. Anadromous fish species such as alewives reportedly continue to migrate up the Acushnet River to spawn. Their migration is stopped by a dam at Hamlin Street. A lower dam at the sawmill has been equipped with a fish ladder.

There are no data on PCB concentration levels in clams and related species from locations north of the Coggeshall Street Bridge because there is little living benthic macrofauna in that area.

3.2.3 Terrestrial Biota

The wetland communities within the study area represent the principal vegetative concern. Sediment samples taken from the cove on the western shore indicate high levels of PCBs and toxic heavy metals that match closely with observed levels in the estuarine sediments immediately outside the cove. Although no data have been collected to date on PCBs and metals in the saltwater marshes along the eastern shore of the harbor, these areas are also likely to exhibit high levels of contamination since they are similarly hydraulically connected to estuarine sediments with PCB concentrations exceeding 500 ppm (see next section). These wetlands, which are dominated by emergent vegetation, may be stressed by the contaminants with a consequential low diversity of plant species.

Fish-eating birds, waterfowl, and other terrestrial animals that feed in the Acushnet River Estuary and mudflat or wetland areas may be adversely affected due to bioaccumulation of PCBs in target organs. PCBs accumulated in fatty tissues can be released as fatty tissue is metabolized, resulting in toxic effects on the animal. Little is known about the ability of animals to resist stresses from PCB intake. Behavioral and reproductive effects are likewise not well documented.

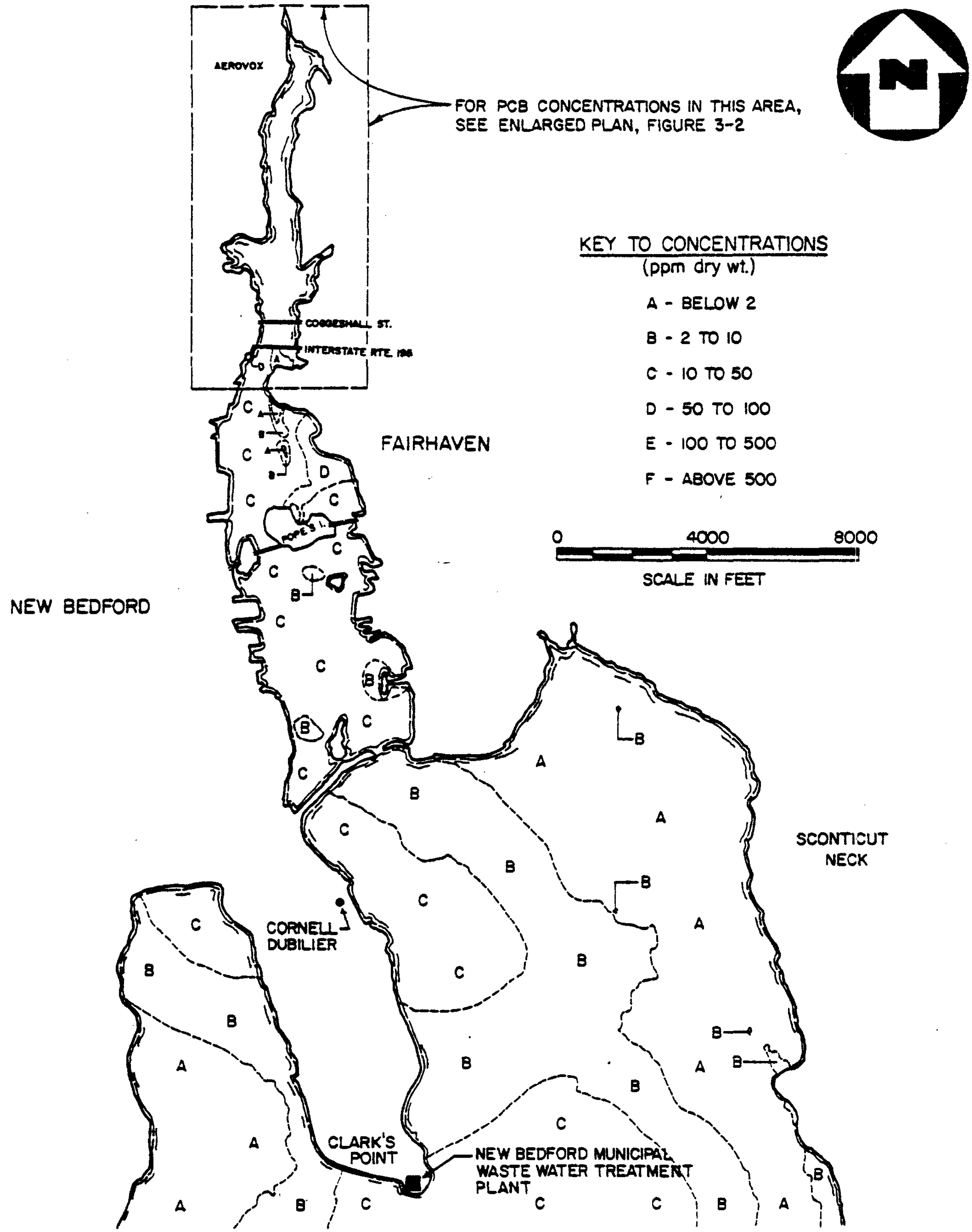
3.2.4 Sediment Contamination

3.2.4.1 PCB Contamination

Figures 3-1 and 3-2 present a statistically-based, graphical representation of maximum PCB concentrations in the sediments of the estuary and harbor. The base map was generated in May 1984 by Metcalf and Eddy using all reliable sediment data. The letters identifying the contaminant level in each zone do not correspond to individual samples or sample locations. Rather, the data base for the statistical development of the zones consisted of hundreds of samples taken over the last several years. Samples from all sediment depths were included in the data base since it is being assumed that even contaminants several inches or centimeters below the surface are susceptible to resuspension and are available to the food chain, and thus are within the scope of any remedial actions.

The concentrations shown are mostly of PCBs measured as Aroclor 1254 and Aroclor 1242. In addition to Aroclors 1254 and 1242, the following Aroclors have been detected in the sediments: 1221, 1232, 1016, 1248, and 1260.

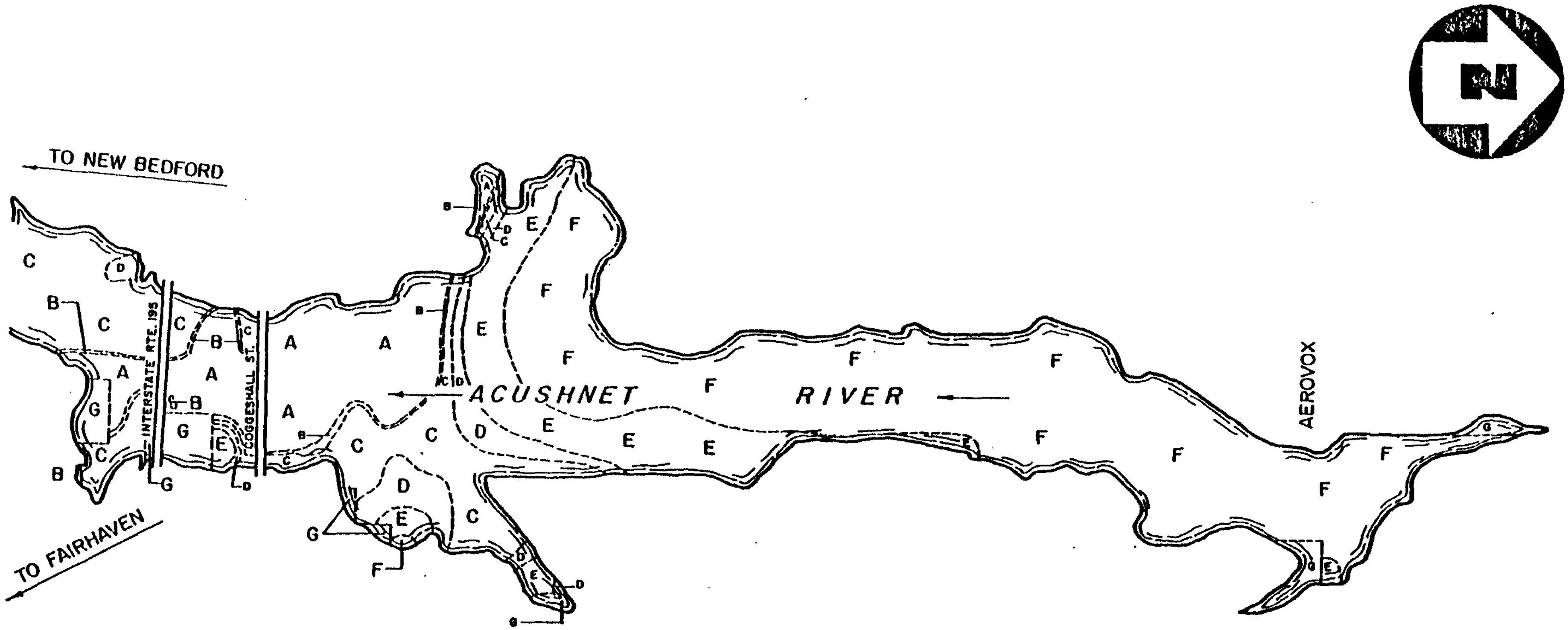
As seen in Figure 3-1, the most severe contamination is restricted to the upper estuary, north of the Coggeshall Street Bridge. The high PCB concentrations in that area appear to emanate from the industrial complex on the western shore of the river. The vicinity of the Aerovox plant has received the highest intensity of sampling. PCB concentrations measured in the area are primarily in the 1,000 to 5,000 ppm (dry weight) range, with some measurements above 100,000 ppm and some below 1 ppm. Samples taken throughout the remainder of the New Bedford Harbor (north of the hurricane barrier) are fairly evenly distributed, as are their



SEDIMENT PCB CONCENTRATIONS
ACUSHNET RIVER ESTUARY
NEW BEDFORD SITE, NEW BEDFORD, MA

FIGURE 3-1

NUS CORPORATION
A Halliburton Company



KEY TO CONCENTRATIONS (ppm dry wt.)

A - BELOW 2
B - 2 TO 10
C - 10 TO 50
D - 50 TO 100
E - 100 TO 500
F - ABOVE 500
G - UNDEFINED

0 1000 2000
SCALE IN FEET

FIGURE 3-2

SEDIMENT PCB CONCENTRATIONS - ACUSHNET RIVER ESTUARY
NEW BEDFORD SITE, NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company

associated PCB concentrations. Between the Coggeshall Street Bridge and the "hot-spot" areas near the industrial complex, concentrations are predominantly in the range of 10 to 500 ppm (dry weight). Along the narrow neck south of the industrial complex and north of the bridge, there is an approximate 0.25-mile stretch of river which has been sampled considerably less than the rest of the harbor, thus concentrations there remain relatively undefined. From the Coggeshall Street Bridge south to the hurricane barrier, PCB concentrations measured have almost all been less than 100 ppm (dry weight), but greater than 1 ppm.

In the Outer Harbor (south of the hurricane barrier) and in Clark's Cove, sediment sampling has been less extensive. The areas offshore of Cornell-Dubilier Electronics, the New Bedford sewage treatment plant at Clark's Point, and the combined sewer overflows in Clark's Cove have received the highest density of sampling, and all three locations have sediment PCB concentrations in the range of 5 to 50 ppm (dry weight). The remainder of the estuary, although sparsely sampled, has PCB concentrations mostly less than 5 ppm (dry weight), with only a few samples falling into higher ranges.

The depth of contamination in the sediment also varies with location in the upper and lower harbor. The highest concentrations in the upper estuary are in the shallow sediments, 4 cm to 8 cm deep. This is probably because PCB discharge to the estuary was ended in 1977, and the most contaminated sediments have been covered by cleaner sediments since then. In the outer portions of the harbor, higher concentrations appear on the maps in the surface sediments than in deeper sediments. However, very few subsurface sediment samples were collected in the areas of highest surface sediment PCB concentration, namely around the treatment plant outfalls, the discharge pipe from Cornell-Dubilier Electronics, and the combined sewer overflows in Clark's Cove. Thus, concentrations in the shallow and deeper sediments in these three areas are unknown.

3.2.4.2 Heavy Metal Contamination

In addition to extensive PCB contamination, the Acushnet Estuary has high levels of trace metals, particularly chromium, copper, lead, and zinc. It has been estimated that the three major contaminant metals (copper, chromium, and zinc) form more than one percent of the dry weight of harbor sediments in some areas. The metals data in the data management system were collected in conjunction with PCB samples and so do not constitute a comprehensive metals data base.

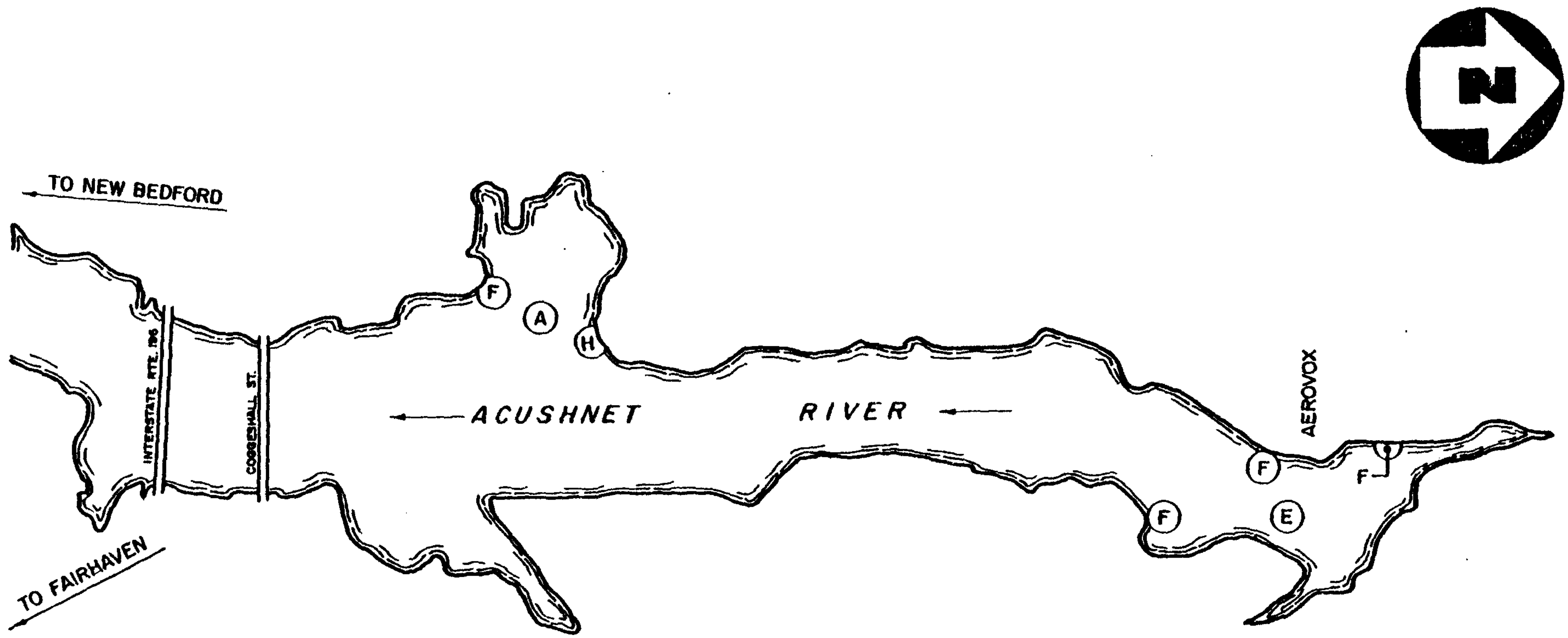
Figures 3-3 through 3-10 present the concentrations of heavy metals in sediment samples taken in the Acushnet River Estuary. The data were mapped in May, 1984 by Metcalf and Eddy. As seen on the figures, the metals samples were taken from upstream of the Aerovox plant, just below the plant, approximately 1100 feet from the plant, and within the cove on the western shore.

3.2.5 Water Contamination

The data management system contains 138 water column analyses in New Bedford Harbor, all of which represent samples taken inside the hurricane barrier. Although concentrations in the water column were, to a large extent, nondetectable (<0.5 µg/l) for other contaminants, levels as high as 6.1 mg/l Aroclors 1248/1254 were measured.

3.3 Public Health and Environmental Concerns

Identification of public health and environmental concerns requires an assessment of real and potential health risks and environmental impacts associated with the hazardous substances in site-specific circumstances. Typically, the risk assessment process involves identification of the hazardous substances of greatest concern, determination of significant exposure pathways and migration routes, and an evaluation of possible health and environmental effects in the context of probable



KEY TO CONCENTRATIONS (ppm dry wt.)

A - BELOW 50	E - 300 TO 400
B - 50 TO 100	F - 400 TO 700
C - 100 TO 200	G - 700 TO 1000
D - 200 TO 300	H - ABOVE 1000

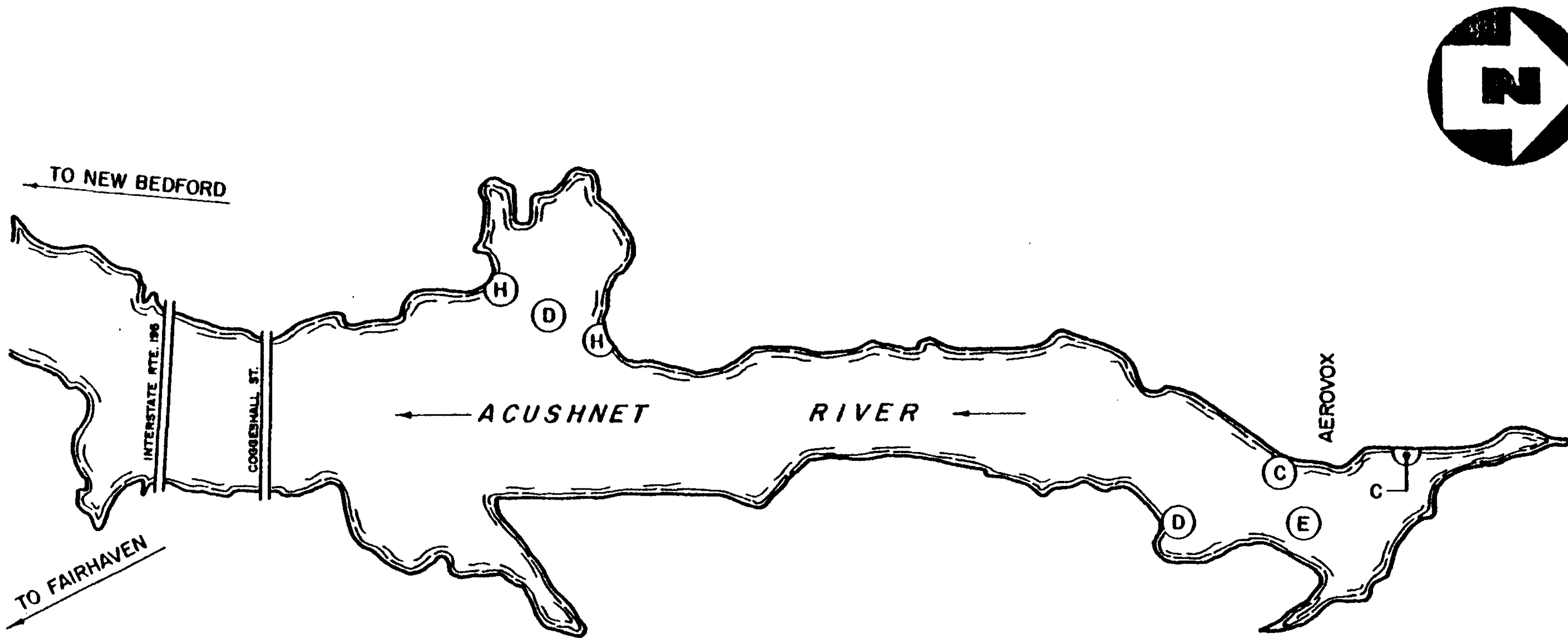
0 1000 2000

SCALE IN FEET

FIGURE 3-3

SEDIMENT COPPER CONCENTRATIONS - ACUSHNET RIVER ESTUARY
NEW BEDFORD SITE, NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company



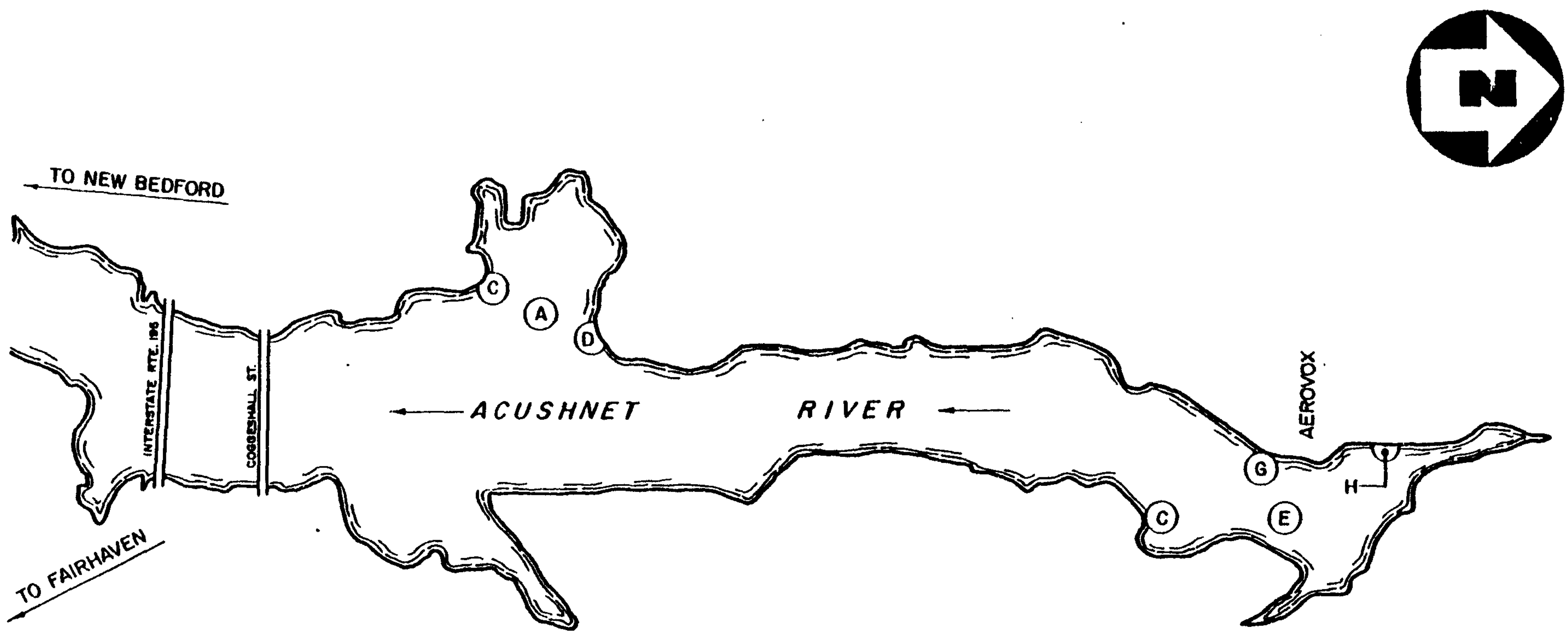
KEY TO CONCENTRATIONS (ppm dry wt.)

A - BELOW 1
B - 1 TO 5
C - 5 TO 10
D - 10 TO 15
E - 15 TO 20
F - 20 TO 35
G - 35 TO 50
H - ABOVE 50

FIGURE 3-4

SEDIMENT ARSENIC CONCENTRATIONS - ACUSHNET RIVER ESTUARY
NEW BEDFORD SITE, NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company



3-16

KEY TO CONCENTRATIONS (ppm dry wt.)

A - BELOW 10	E - 150 TO 200
B - 10 TO 50	F - 200 TO 300
C - 50 TO 100	G - 300 TO 500
D - 100 TO 150	H - ABOVE 500

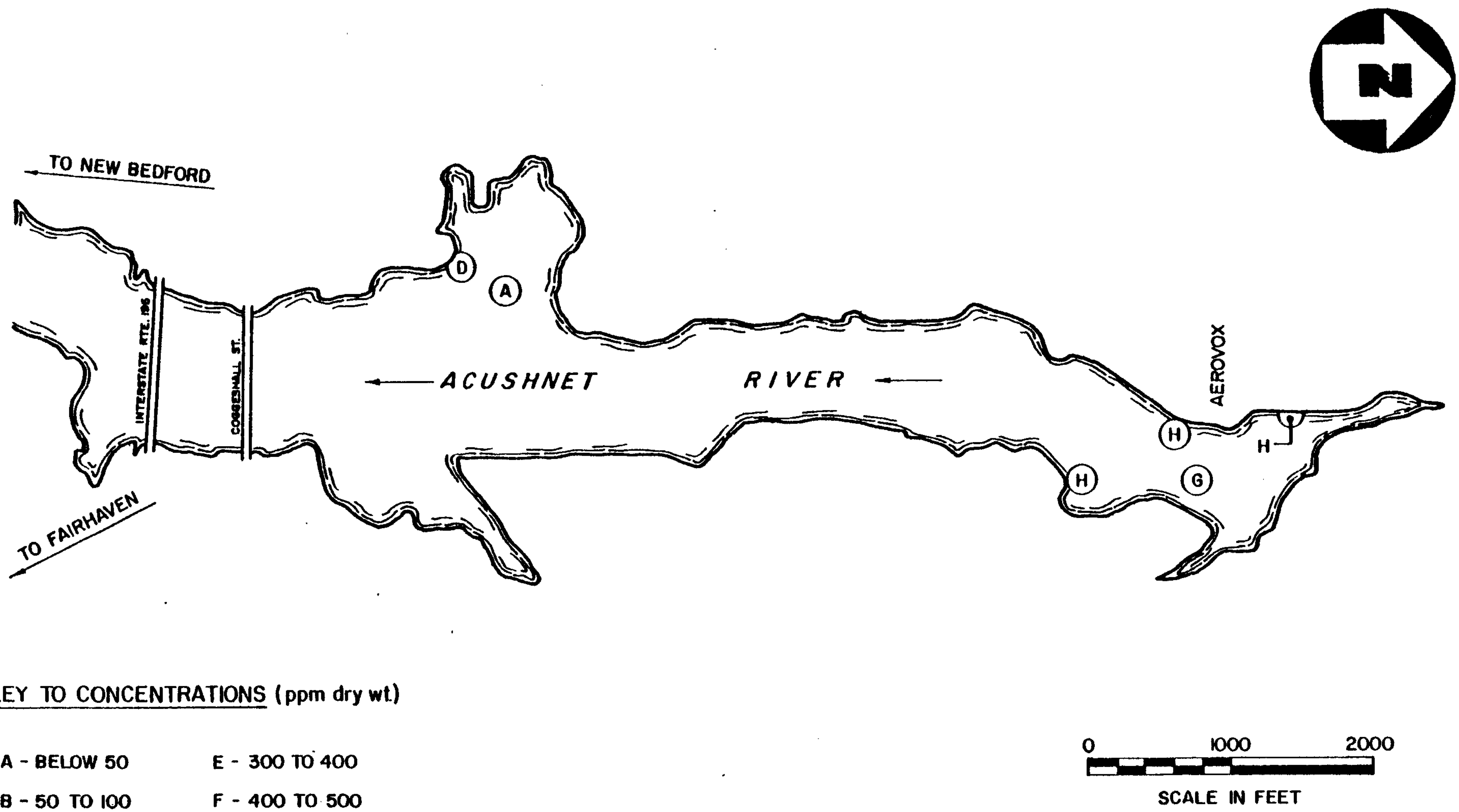
0 1000 2000

SCALE IN FEET

FIGURE 3-5

SEDIMENT LEAD CONCENTRATIONS - ACUSHNET RIVER ESTUARY
NEW BEDFORD SITE, NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company



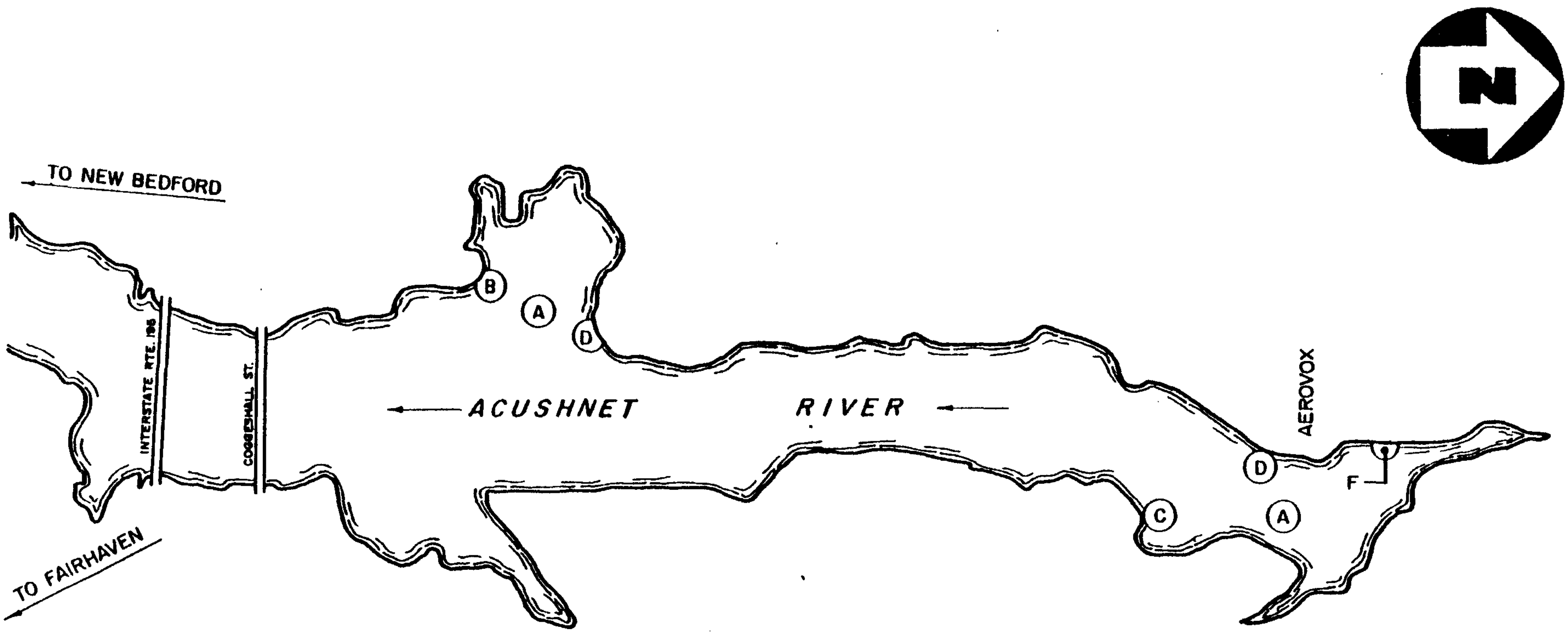
KEY TO CONCENTRATIONS (ppm dry wt)

A - BELOW 50
B - 50 TO 100
C - 100 TO 200
D - 200 TO 300
E - 300 TO 400
F - 400 TO 500
G - 500 TO 600
H - ABOVE 600

FIGURE 3-6

SEDIMENT ZINC CONCENTRATIONS - ACUSHNET RIVER ESTUARY
NEW BEDFORD SITE, NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company



KEY TO CONCENTRATIONS (ppm dry wt.)

A - BELOW 0.1	E - 1.0 TO 1.5
B - 0.1 TO 0.3	F - 1.5 TO 2.0
C - 0.3 TO 0.5	G - 2.0 TO 2.5
D - 0.5 TO 1.0	H - ABOVE 2.5

0 1000 2000

SCALE IN FEET

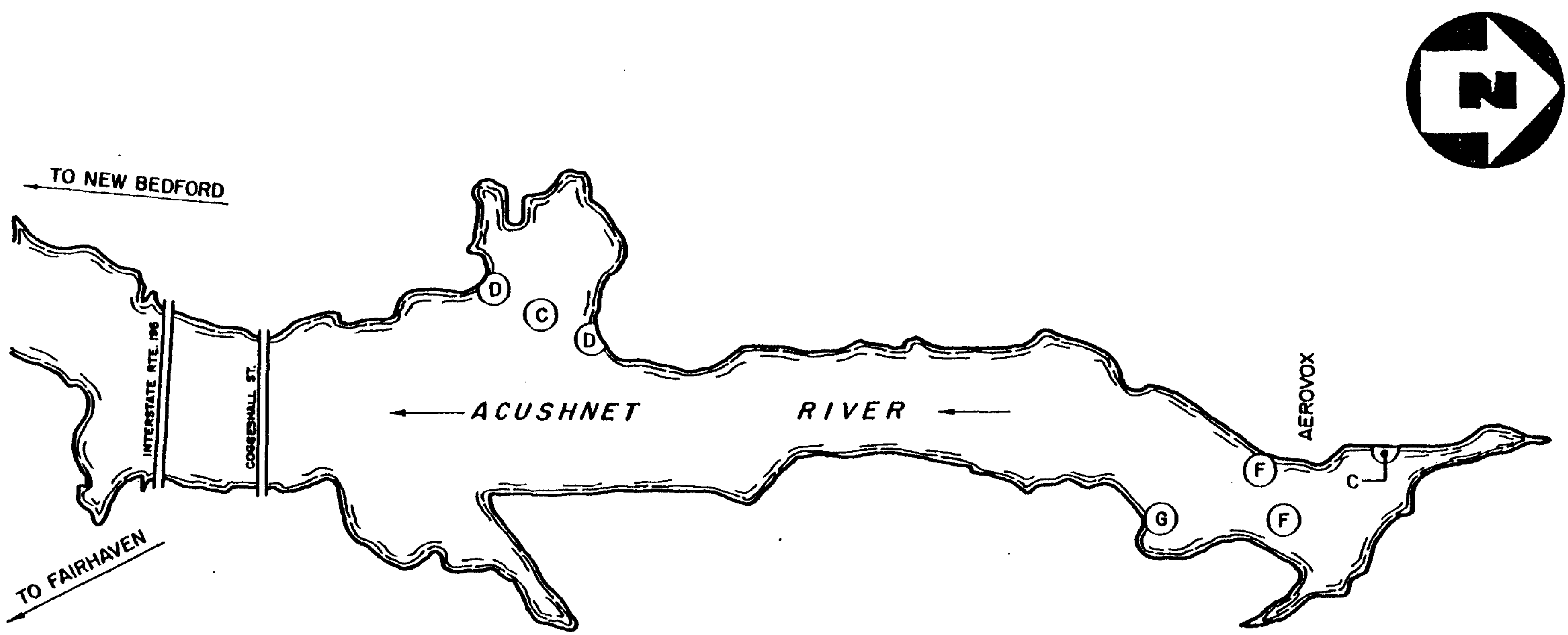
FIGURE 3-7

SEDIMENT MERCURY CONCENTRATIONS - ACUSHNET RIVER ESTUARY

NEW BEDFORD SITE, NEW BEDFORD, MA

NUS CORPORATION

A Halliburton Company



KEY TO CONCENTRATIONS (ppm dry wt.)

A - BELOW 10	E - 200 TO 300
B - 10 TO 50	F - 300 TO 400
C - 50 TO 100	G - 400 TO 500
D - 100 TO 200	H - ABOVE 500

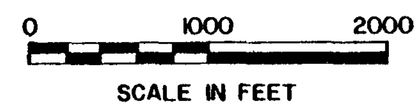
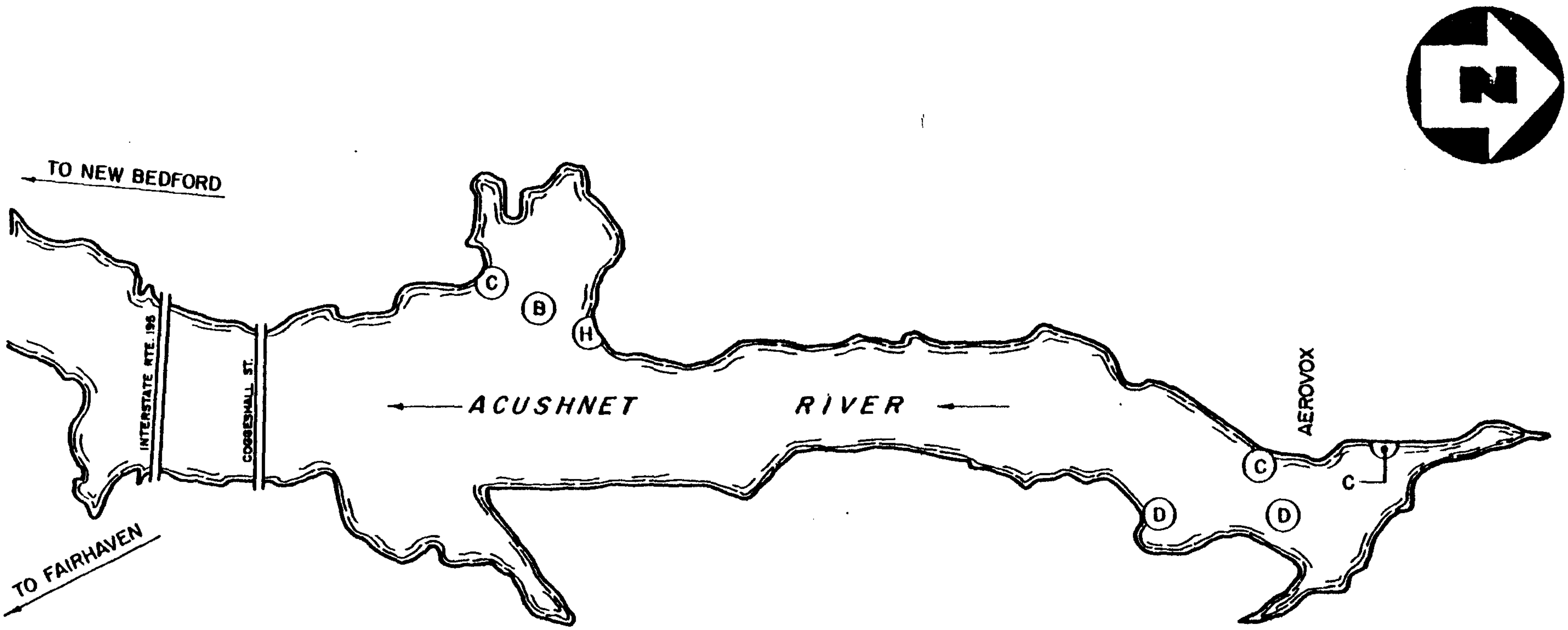


FIGURE 3-8

SEDIMENT CHROMIUM CONCENTRATIONS - ACUSHNET RIVER ESTUARY
NEW BEDFORD SITE, NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company



3-20

KEY TO CONCENTRATIONS (ppm dry wt.)

A - BELOW 10
B - 10 TO 25
C - 25 TO 50
D - 50 TO 75
E - 75 TO 100
F - 100 TO 125
G - 125 TO 150
H - ABOVE 150

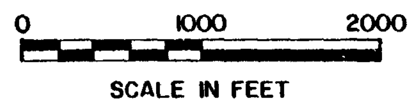


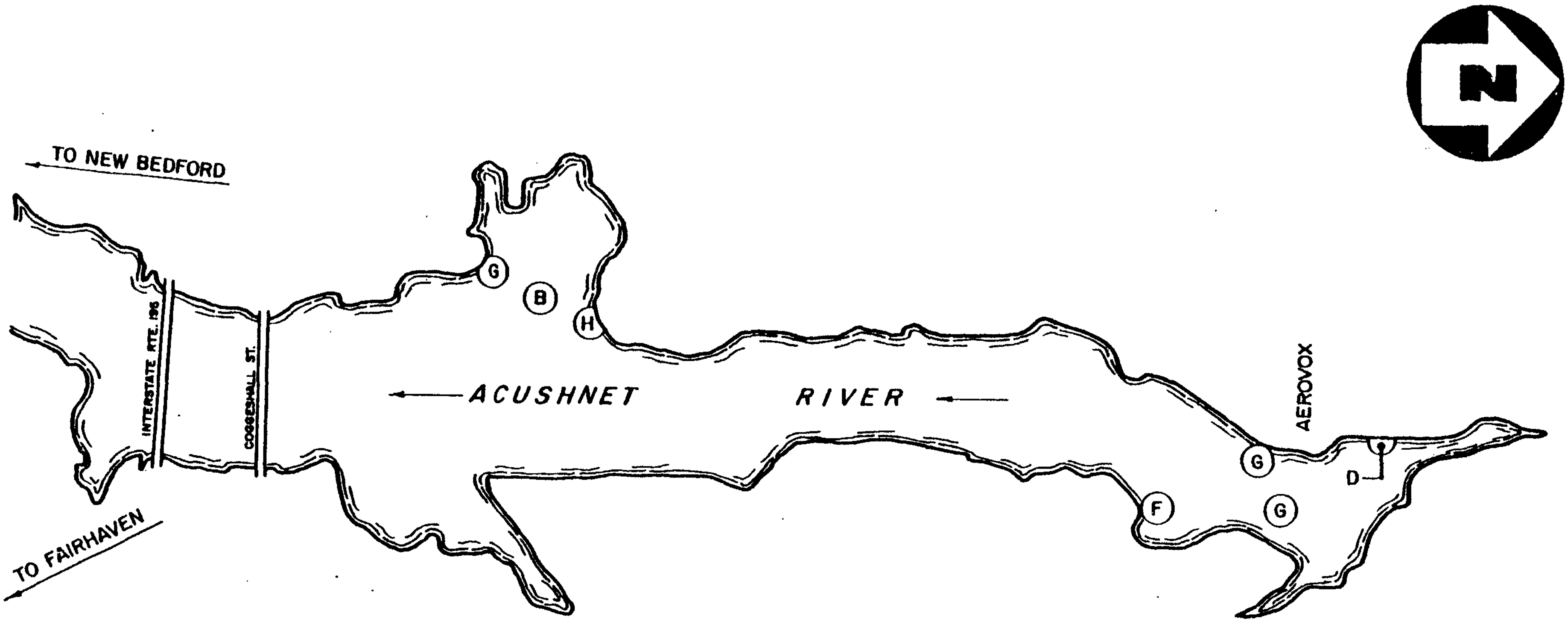
FIGURE 3-9

SEDIMENT NICKEL CONCENTRATIONS - ACUSHNET RIVER ESTUARY

NEW BEDFORD SITE, NEW BEDFORD, MA

NUS CORPORATION

A Halliburton Company



KEY TO CONCENTRATIONS (ppm dry wt.)

A - BELOW 1
B - 1 TO 3
C - 3 TO 5
D - 5 TO 7
E - 7 TO 10
F - 10 TO 15
G - 15 TO 20
H - ABOVE 20

0 1000 2000

SCALE IN FEET

FIGURE 3-10

SEDIMENT CADMIUM CONCENTRATIONS - ACUSHNET RIVER ESTUARY
NEW BEDFORD SITE, NEW BEDFORD, MA

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exposure scenarios. Several factors must be considered during the implementation of this process. These include:

- Present conditions in the estuary, as defined by the reconnaissance and pertinent studies already undertaken and completed.

- Physical, chemical, environmental, and biological variables affecting the mobility and environmental fate of the contaminants.

- Potential human receptors and environmental entities, and their likelihood of exposure and susceptibility to the hazardous substance.

- Health effects and environmental impacts linked with exposure to those compounds, including any ascertainable additive, synergistic, or inhibitory effects.

Any limitations on the extent to which these factors can be evaluated will limit the scope of the risk assessment and inferred conclusions. This assessment is based largely on chemical analytical data gathered during past studies that were not specifically planned around health and environmental risk assessments. Consequently, the assessment is mainly based on the expected behavior of the particular contaminants in the general site environment.

3.3.1 Selection and Evaluation of Representative Environmental Contaminants

Environmental contaminants were selected for inclusion in this assessment primarily in the context of potential human health impacts. The presence and definition of the contaminants was established from previous studies. Major contaminants found in each of the sampled environmental media (air, water, soils, sediments) and particularly in the aquatic biota are presented in Section 3.2. In order to identify and classify the potential risks posed by these contaminants, it is necessary to assess their toxic properties and the relative probabilities of exposure to them. This is achieved by first selecting and evaluating those compounds which are most likely to migrate through or persist within the media, and thereby provide a gross measure of exposure probability. Then, by further considering such factors as associated toxic and carcinogenic properties of the pure compounds, observed maximum concentrations, frequency of detection, and comparison to such criteria as the Ambient Water Quality Criteria, Drinking Water Standards, and other relevant criteria and standards, the "critical" or representative contaminants may be selected. This method results in identification of those compounds which are most representative of the overall site hazards, and permits a relative assessment of the risks they pose.

3.3.2 Potential Human and Environmental Receptors

In order for an exposure pathway to be complete, three elements must be present: a source of contamination, a route of contaminant transport, and receptors within or at the end of that route. In the case of the Acushnet River Estuary defined in this report, the upper estuary represents the source of contamination. Mobility and the most likely environmental fate of the identified contaminants point toward the transport routes. Potential receptors include:

- Consumers of contaminated fish, aquatic birds, and mammals.
- Population living in the immediate vicinity of the shores where direct contact or inhalation of contaminants may be possible.
- Recreational users of the waters and shores of the estuary.

- Consumers of contaminated drinking water.

- Clean-up personnel.

3.3.3 Potential Health and Environmental Risks: Airborne Contaminants

<u>PCBs</u> - As discussed in Section 3.2.1, a 1982 areawide ambient air monitoring program included five stations near the hot-spot area. Two stations were generally in the upwind direction, and three were sited on downwind vectors to the north and east of the site. The two upwind stations had total PCB concentrations averaging 10 to 11 ng/m^3, which represent typical background readings for PCBs in an urban environment. Downwind PCB concentrations to the north were significantly higher, with values of 83 ng/m^3 and 92 ng/m^3. A station located in Acushnet to the east-northeast of the site had PCB concentrations ranging from 51 ng/m^3 to 88 ng/m^3.

The United States presently does not have ambient air standards for PCBs. Therefore, it is difficult to assess the significance of the elevated PCB concentrations near the hot spots. Some insight can be gained by an ambient air guideline for PCBs established by the Canadian Ministry of the Environment. The level established for Canada is 150 ng/m^3 as a 24-hour average. Measured PCB levels near the hot-spot areas do not exceed the Canadian guidelines, and thus no immediate risk to public health appears to exist as a result of short-term exposures to the PCB levels observed.

On the other hand, a potential public health concern is the long-term exposure to measured PCB concentrations that are approximately an order of magnitude (10 times) higher than typical background levels in urban areas. For example, Boston has a reported PCB level of 7.1 ng/m^3. Even though the effects of such an exposure are uncertain, an increase of this magnitude over background levels is considered to result in an elevated risk to the potential receptors.

Heavy Metals - The major toxic heavy metals reported to be present in the hot-spot areas that have associated health implications if inhaled as dusts or vapors are cadmium, chromium, and lead. The evaluation of these heavy metals in air is limited by the relevance and quality of available data. Collected particulates were chemically analyzed for toxic heavy metals in the GCA air study program, but the chemical analytical protocol did not yield results which quantify the most toxic (via inhalation) form of the heavy metal, i.e., hexavalent chromium or specific lead and cadmium compounds.

The maximum concentrations of metals measured at the downwind locations indicate that there are no significant public health risks associated with the airborne release of metals from the hot-spot areas. In the case of lead, the observed maximum concentration of 445 ng/m^3 is approximately one-third of the National Ambient Air Quality Standard of 1500 ng/m^3 (90-day average). It is not expected, however, that the hot-spot area is the source of the atmospheric lead. The source is more likely industrial discharges or automobile and boat exhausts (leaded gasoline).

3.3.4 Potential Health and Environmental Risks: Sediment Contaminants

The concentrations and distribution of PCBs and toxic heavy metals in the sediments of the Acushnet River Estuary are reported in Section 3.2.4. The distribution pattern defined by the studies is subject to change with time due to transport of the sediments by water movement, storm events which may cause resuspension, and other physical disturbances and food chain interactions. Exposure potential may also change due to physical changes in conditions, i.e., covering of the contaminants by clean sediments.

Figure 3-2 displayed the concentration pattern for PCBs in the sediment for the study area. Most of the area has concentrations exceeding 500 mg/kg (dry weight). The description does not distinguish between underwater and exposed sediments.

Since this is a tidal estuary, a significant portion of the estuary will be exposed at low tide providing the opportunity for direct contact by the human and environmental receptors.

Figures 3-3 to 3-10 showed the distribution of toxic heavy metals at seven sampling locations in the upper estuary. The distribution pattern of the species and concentrations of the various heavy metals is variable. Maximum concentrations of the heavy metals were not observed in a single location. A gross characterization of the analyses is as follows: copper, above 1,000 mg/kg; arsenic, above 50 mg/kg; lead, above 500 mg/kg; zinc, above 600 mg/kg; mercury, above 2.5 mg/kg; chromium (total), above 500 mg/kg; nickel, above 150 mg/kg; cadmium, above 20 mg/kg.

Even though ingestion of the contaminated sediment is not likely, there is the potential for direct contact (dermal exposure) by human receptors using the shoreline for various activities such as clamming, fishing, or recreational use even though all fishing and clamming activities have been prohibited by the Commonwealth of Massachusetts due to the high PCB content. The pure PCB chemical is known to readily pass through the dermal barrier. It is not clear whether PCBs adsorbed on the sediments as an oily film should be considered in the same category, but in the absence of any data it is prudent to conclude that there is some potential for intake of PCBs by direct contact with the sediments.

The potential risks associated with direct exposure to contaminated sediments containing high levels of PCBs include acute and chronic toxicity, suspected carcinogenic effects, and possibly reproductive effects. The effects of acute or chronic toxicity caused by exposure to high levels of PCBs could include nausea, vomiting, weight loss, swelling of the joints, jaundice, digestive disorders, and chloracne. In the case of PCB intake via diffusion through the skin, no threshold limits (i.e., concentrations below which it can be considered that there are no effects) can be set. As a result, the degree of risk cannot be quantified or completely defined.

The critical exposure pathway originating in the sediments is the ingestion of contaminated aquatic and terrestrial food (e.g., fish, birds, and game) that have been directly or indirectly exposed to the contaminated sediments via the food chain. PCBs are highly bioaccumulative, meaning that they accumulate over time with very little reduction and are not readily eliminated during metabolism in the biota or man. In addition, PCBs are not easily degraded and are highly persistent in the sediments. Consequently, they will remain available to uptake in the food chain if there is no alteration in site conditions. The ultimate risks posed by the contaminated food sources are addressed in the next section.

3.3.5 Potential Health and Environmental Risks: Aquatic Food Chain

PCBs - The presumed pathway of human exposure to PCBs is transport of the contaminants from the bottom sediments to bottom-feeding aquatic life and to the water column, up the food chain to the higher organization biota via ingestion of the bottom feeders and water, and finally to man. Section 3.2.2 describes the current levels of contamination of food fish and other aquatic species that stem mainly from the presence of PCBs and metals in the sediment and water.

The potential health risks associated with the ingestion of PCB-contaminated food sources include the following:

- Acute Toxicity - This is defined as exposure to the contaminant either as a single episode or for a short time period. Available, though limited measures of acute toxicity are oral LD_{50} values (lethal dose at which 50 percent of test animals died) of 4,250 ppm for Aroclor 1242 and 1,010 ppm for Aroclor 1254 for rats. If these values are extrapolated to man, it is likely the levels of contamination in food sources from the estuary pose a minimal risk of acute toxicity.

- Chronic Toxicity - This is associated with any toxic effect observed as a result of chronic (long-term) exposure to sub-lethal doses of PCBs. Various criteria to assess potential chronic toxicity are possible. One is the FDA action level of 2 ppm PCBs in the edible portion of fish or shellfish, which has been established as a safe level with acceptable risks for human consumption. It has been previously discussed that many critical species currently exceed this level in the Acushnet River Estuary and New Bedford Harbor. An even more stringent measure of chronic toxicity is the Allowable Daily Intake (ADI), which is based on the Lowest Observed Adverse Effect Level (LOAEL) for reproductive effects in one animal and includes an uncertainty factor of 1,000. The ADI for PCBs is 0.021 mg/day, which would be exceeded if more than 2 grams of fish with PCB concentrations exceeding 10 ppm are eaten per day. Obviously, the ADI will be exceeded if contaminated fish or shellfish are eaten on a regular or even intermittent basis.

- Carcinogenicity - Animal tests have indicated that there is an association between carcinogenic tumor production and PCBs. An appraisal of the data base by the International Agency for Research in Cancer (IARC) categorizes various aroclors as positive animal and suspected human carinogens (IARC Monograph, Supplement 4, 1982). A measure of carcinogenic potency has been developed by the Carcinogenic Assessment Group (CAG) in EPA that uses the slope of the linear portion of the dose-response curve in animal studies (modified by the molecular weight of the chemical). Factors are presented as orders of magnitude and a comparison can be made between the 54 suspected human carcinogens that were assessed. PCBs have been assigned a potency factor of 3. In the spectrum of carcinogenic potency, i.e., distribution of the factor: 11 of the 54 chemicals had a higher potency, 17 were assigned the same risk, and 26 had a lower assigned carcinogenic potency factor. The factors are based mainly on animal oral studies. EPA considers PCBs to be possible carcinogens. Curently, there is no known safe level of exposure to carcinogens.

Heavy Metals - The completion of an exposure path between human receptors and the toxic heavy metals contained in the sediments has not been established. In the marine environment, these contaminants are probably immobilized. Solubilities of the heavy metals (in water) in the probable form, as sulfides, is low. The absence of available chemical analytical data related to the surface water in the estuary limits the assessment of health risks and environmental impacts associated with the presence of the heavy metals. Based on the expected immobility of the toxic heavy metals in a marine sediment, however, concentrations above background or detection levels may not occur in the water column.

Health risk issues associated with the particular heavy metals are the following:

- Exposure of human receptors to the sediment heavy metals would normally take the same path as that described for the PCBs. In addition, any remedial measure implemented for the potential PCB contamination problems would also address the toxic heavy metals. Direct exposure to the sediments would not pose a health risk as dermal exposure to metals does not have any related health impacts. Toxic heavy metals will not pass through the dermal barrier, at least in the form in which they are present in the sediments.

- Acute Toxicity - Ingestion of sediments is not likely and the threshold value for acute toxic effects would not be exceeded in any hypothesized scenario.

- Chronic Toxicity - ADIs might be exceeded by ingestion of contaminated marine fish and invertebrates. Consequently, there is some potential for health impacts. However, without any available baseline data relating to heavy metal concentrations in edible fish and invertebrate tissues, an assessment is limited. In the case under study, PCBs are a more important public health factor than metals.

- Carcinogenicity - 5 of the 8 toxic heavy metals found in the estuary sediments are associated with some form of carcinogenicity. These include arsenic, lead, chromium, nickel and cadmium. However, only specific compounds are presently associated with human or animal carcinogenicity. All of the reported carcinogenic metallic compounds would not be expected to occur in the site-specific circumstances, i.e., in marine sediments. Consequently, the relevance of carcinogenicity data in this site-specific context is questionable.

3.3.6 Potential Health and Environmental Risks: Surface Water and Groundwater

Surface Water - As well as can be determined, PCB concentrations in the surface waters of the estuary may not be an important exposure pathway for human receptors because the estuary is not a potable water supply. Impacts on the aquatic biota in terms of aquatic toxicity cannot be evaluated, but is likely to be small in comparison with contributions from the sediments and food chain.

Groundwater - Although the site is defined as a marine estuary and drinking water is not associated with the site, some assessment of the potential for contaminant migration to potable water taken from the regional groundwater regime is needed. As discussed in other sections, there is only a remote possibility of any linkage between the potable water supply and the marine estuary. In addition, because of the low solubility of PCBs and metals, the possible ingestion of contaminants from groundwater will be low in comparison to the other exposure pathways just described.

3.4 Public Welfare Issues

The intent of this seciton is to provide an overview of the socioeconomic settling within the study area and to identify the principal, potential impacts on waterfront development and commercial activities caused by the environmental contamination. *A more detailed study of these issues will be conducted by the* Federal Government, and thus the information contained herein should be considered tentative and subject to revision.

3.4.1 Harbor Land Use and Development Plans

Waterfront development plans have been linked with the expansion of fishing and other marine-related industries. Additional berthing areas are desired along the deep-water shoreline in order to accommodate a greater number of ships. The creation of additional industrial land and docking areas has been proposed through land fill and bulkheading of dredge material. The largest developable site currently available in the harbor area is the North Terminal. Land available there may be of interest to a diverse group of marine-related industries. The low vertical clearance and repeated failures of the hydraulic system of the Route 6 Bridge are viewed as contributing factors to the slow development of the North Terminal. Replacement of the Massachusetts Route 6 bridge has been deemed necessary in order to reduce the number of bridge openings and open the northern harbor to ships of all sizes. Recreational and tourist uses of the waterfront have also been encouraged within the past decade. Tourist trade in the downtown Historic District has been increasing, and there is much interest in constructing a recreational marina on Pope's Island, which is located on the southern side of Route 6 as it crosses the New Bedford Harbor (New Bedford Planning Department, 1984).

Officials from New Bedford and Fairhaven established the joint Harbor Master Planning Committee in 1976 to consider issues and recommend policies related to harbor development. As part of this task, the Committee adopted the following as its planning goal:

> To enhance the community's economic development goal by providing ample opportunities for stable employment by either maintaining or expanding *existing harbor industries, retaining and protecting the* existing fishing industry, or introducing new harbor-related industries (New Bedford Planning Department, 1977).

The Committee recognized several objectives as having the highest priority for economic development, including guaranteeing the fishing fleet's continued accommodation at modern piers, setting aside suitable vacant land for future fishing industry development, and guiding potential oil exploration activities to sites which meet oil industry needs and cause the fewest conflicts with harbor-related activities.

As part of the New Bedford/Fairhaven Harbor Master Plan, a land use study was completed in 1977 to determine the allocation and use of land adjacent to the harbor. The study area included 637 acres of land on both sides of the harbor. Approximately 330 of those acres are south of the bridge. Six different land classifications reflected the harbor's various uses for the purposes of that study: 1) Domestic (residential, cultural, entertainment, and recreational); 2) Manufacturing; 3) Marine related (fishing marinas, retail sale of small boats, boatyards and shipyards, and warehouse storage); 4) Commerce and services; 5) Transportation and communication utilities; and 6) Vacant buildings and undeveloped land. Survey results show the following breakdown of land uses:

	Acres	Percent of Total
Domestic	95	15
Manufacturing	66	11
Marine-related	28	4
Commerce	79	12
Transportation	205	32
Vacant	164	26
	637	100

In the New Bedford - Fairhaven Harbor Master Plan, the harbor is viewed as six different entities: 1) a fishing port, 2) a cargo port, 3) a potential center of water-related manufacturing, 4) a potential support base for offshore oil exploration and production, 5) an attraction which can stimulate tourist trade and promote downtown revitilization, and 6) a human habitat, as the harbor area is the residential setting for over 1,600 people in New Bedford and Fairhaven. These six different views of the harbor reflect the development goals and issues related to the waterfront and harbor. Each of the harbor views and the related development goals are discussed below.

Fishing Port - New Bedford and Fairhaven's fishing harbor area contains harbor approaches, channels, turning basins, piers, bulkheads, loading and unloading areas, highways and streets, parking facilities, repair services, processing facilities, wholesale supplies, and retail outlets. Significant development issues related to the fishing industry included the extension to a 200-mile limit on fishing fleet activity by the federal government, and identification of future harbor space needs associated with fleet expansion.

Cargo Port - The harbor area functions as a cargo port by accommodating primary, secondary, and auxiliary port uses at the State Pier. Examples of each of these port uses are the cargo shed, the loading area, and the cargo transit area, respectively. As part of the Harbor Master Plan, the policy of encouraging State Pier growth was adopted. Further development of the Pier involves land use planning, including transportation circulation patterns, and the maintenance, improvement, and expansion of docking facilities. Maintenance of the harbor itself can be considered a primary economic development priority for the harbor as part of both the fishing port and cargo port views of the harbor.

Center of Water-Related Manufacturing - Vacant land along the harbor shoreline has much potential for development. Some of the tracts have adequate rail and highway access, sufficient provision of utilities, and easy access to deep water channels. The expansion of water-related manufacturing would require that each of these elements be at a suitable level for development of individual parcels.

Support Base for Offshore Oil Exploration - Planning issues related to offshore oil exploration and production include the identification of suitable vacant tracts for a support base and the recommendation of development controls to minimize conflicts between oil and fishing activities (New Bedford Planning Department, 1977). The eventual use of the harbor as a support base for offshore oil exploration will be greatly influenced by the development of the offshore oil industry itself.

Attraction for Tourists - One view of the harbor is that the waterfront scenery is an attraction which can stimulate tourist trade and promote downtown revitalization. The Harbor Master Plan reports that:

> The ever-changing presence of a lightship, lobster boats, trawlers, repair yards, draggers, freighters, and Coast Guard cutters, combined with fine museums, architecturally significant residences, and the waterfront's 19th Century setting, provides a tourist attraction unique in all the nation (New Bedford Planning Department, 1977).

As part of developing the tourist potential, strategies to connect the opposite shoreline and provide access between retail districts and the waterfronts were recommended.

Human Habitat - To protect the residences along the waterfront, careful planning to preserve and enhance the environment was called for in the Master Plan. The creation of additional waterfront settings for leisure and cultural activities, in such a fashion as to not interfere with economic activities, was another goal specified in the plan. Carefully planned recreational, cultural, and residential uses are seen as a tool to stimulate the economics of New Bedford and Fairhaven.

3.5.2 Waterfront Development Constraints and Impacts Due to Environmental Contamination

Even though more than 200 commercial fishing vessels are moored in New Bedford Harbor, commercial fishing takes place outside of the harbor. The New Bedford Harbor inside the hurricane barrier is permanently closed to shellfishing and the taking of bottom-feeding fish and lobsters. Outside the hurricane barrier, a large area is closed to shellfishing due to high levels of PCBs. Bottom-feeding fish and lobster are also not allowed to be taken from this area because of PCB contamination (New Bedford Facilities Plan, draft).

There is also a great deal of concern related to any possible dredging in the harbor as it may stir up contaminants. The disposal of contaminated dredge spoils is also a serious constraint. As stated in the 1977 Harbor Master Plan, "serious study must be given to the question of dredge disposal techniques which will not seriously impair environmental quality" (New Bedford Planning Department, 1977). To function as a fishing and cargo port, the New Bedford Harbor must be dredged and maintained in order to accommodate large ocean-going vessels. If the harbor is not maintained, it is possible that important manufacturing concerns, such as fish processing plants, will move to other ports. In order to function as a support base for offshore oil exploration in the future, deep water channels will be needed and therefore dredging will be required.

Another development constraint related to PCB contamination and the current inabililty to dredge in the harbor is the lack of a replacement for the New Bedford/Fairhaven (Route 6) Bridge. The bridge was built in 1903 and over the years it has become less dependable as the frequency of hydraulic system breakdowns has increased (New Bedford Planning Department, 1978). The narrow width of the bridge opening restricts the size of ships thay may proceed to the northern half of the harbor, and therefore limits the type of cargo shipments that may be sent or received from present or future businesses there.

A major impact of the development constraints on the fishing industry is that fishermen are unable to fish in the harbor and adjacent waters, thus increasing the distance of fishing areas and the cost of obtaining certain fish and shellfish. All boats using the harbor depend upon safe navigation routes. An inability to carry out dredge and fill operations could block the creation of additional berthing space needed for an expanding fishing fleet and other ships that use the harbor. Regular channel maintenance is also needed to maintain harbor safety for the fishing fleet.

Another factor that may affect the future location and expansion of the fishing fleet is whether or not the fish processed near the harbor are perceived as contaminated simply because sediments in New Bedford Harbor contain PCBs.

Development constraints may also cause impacts to the recreation and tourism activites that occur in the New Bedford area. The development of new marinas may require dredging operations for construction and to maintain channel access routes. Unless new marinas are built, the number of mooring spaces cannot be increased and expansion of retail trades and services that serve these boats will be curtailed. An inability to use the harbor water for swimming or fishing reduces both the general recreational opportunities available and the demand for recreational boating. The desire to integrate recreation facilities, such as pedestrian walkways and other circulation paths, with development on the shoreline is related to the expansion of business along the waterfront.

Together these physical development constraints cause impacts upon the New Bedford regional area and its future economic development. There are impacts on the harbor as a fishing port, cargo port, and as a tourist attraction and human habitat. Impacts to the fishing industry are very important, as several related industries are affected.

4.0 INITIAL SCREENING OF REMEDIAL ACTION TECHNOLOGIES

4.1 *Purpose of Initial Screening*

The remediation of the hot-spot areas in the Acushnet River Estuary is a complex undertaking due to the wide range of interactive technical, regulatory, socioeconomic, environmental, and health issues. Technically, the relatively distinct chemical character of the PCBs and heavy metal contaminants introduces special considerations relative to other types of hazardous waste. The physical and chemical processes controlling flow and contaminant transport within the estuary/harbor/.bay system are many and varied, and the great volume of contaminated sediments to be dealt with introduces a significant constraint on the potential options. From a regulatory standpoint, complexities arise due to the following:

- PCBs maintain a "special waste" classification under the current Massachusetts state regulatory framework.

- Precedent-setting actions are lacking under the Commonwealth of Massachusetts' hazardous waste laws and policies, since they are being developed and finalized concurrently with this study.

- Additional regulatory controls may be exerted by various federal and state agencies due to the water-based, coastal setting of the project.

- There are differences in the regulations in relation to "offsite" versus "onsite" removal/disposal options.

The socioeconomic issues focus on the potential impacts of the actions (e.g., disposal of contaminated dredge materials) and the sensitivity of these issues to those directly affected. Environmentally, each potential action has some degree of impact on the indigenous aquatic resources of the study area, which include fish, crustaceans, freshwater wetlands, salt marshes, etc.

For these reasons, the fast-track Feasibility Study had to be comprehensive in the types of potential remedial actions considered. The number of technologies and combinations of technologies were excessive; thus, it became necessary to undertake a phased selection process. At each phase of this process, additional selection criteria were introduced, and a more detailed analysis of technologies or alternatives was conducted toward the objective of progressively retaining only the most feasible alternatives.

The purpose of the initial screening was to identify and assess all existing technologies applicable to the remediation of PCB contamination, and to eliminate technologies that are not technically feasible or that do not have a proven performance record for the intended application. The latter criterion is a requirement of the National Contingency Plan, and caused the elimination of numerous technologies in this initial screening phase.

4.2 Selection of Technologies

The individual technologies identified for review can be organized into three general remedial action scenarios. With reference to Figure 4-1, the scenarios include the following.

- The no-action alternative (i.e., maintain the "as is" condition).

- Non-removal actions, which involve technologies directed toward the reduction of contaminant risk without removing the contaminated material (i.e., the hot-spot sediments). An option under this category is the construction of hydraulic control structures to eliminate the transport of contaminants to New Bedford Harbor and Buzzards Bay, in possible conjunction with backfilling or capping the local sediments to reduce the public health and environmental risks. The other option is the in-situ treatment of the contaminated sediments by chemical fixation, biodegradation, or particle radiation.

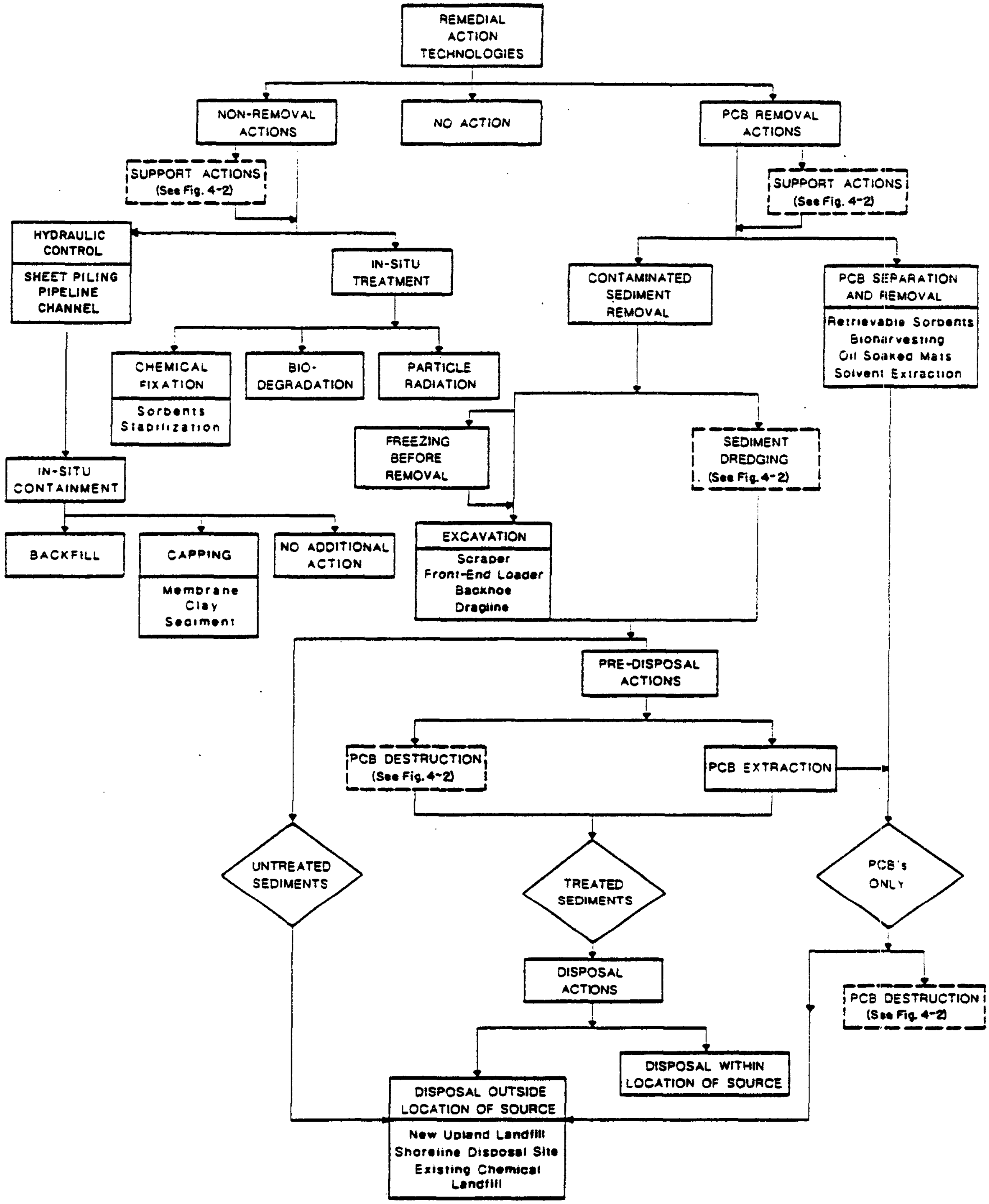

FIGURE 4-1

TECHNOLOGIES/ALTERNATIVES IDENTIFIED FOR PRELIMINARY SCREENING PROCESS
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

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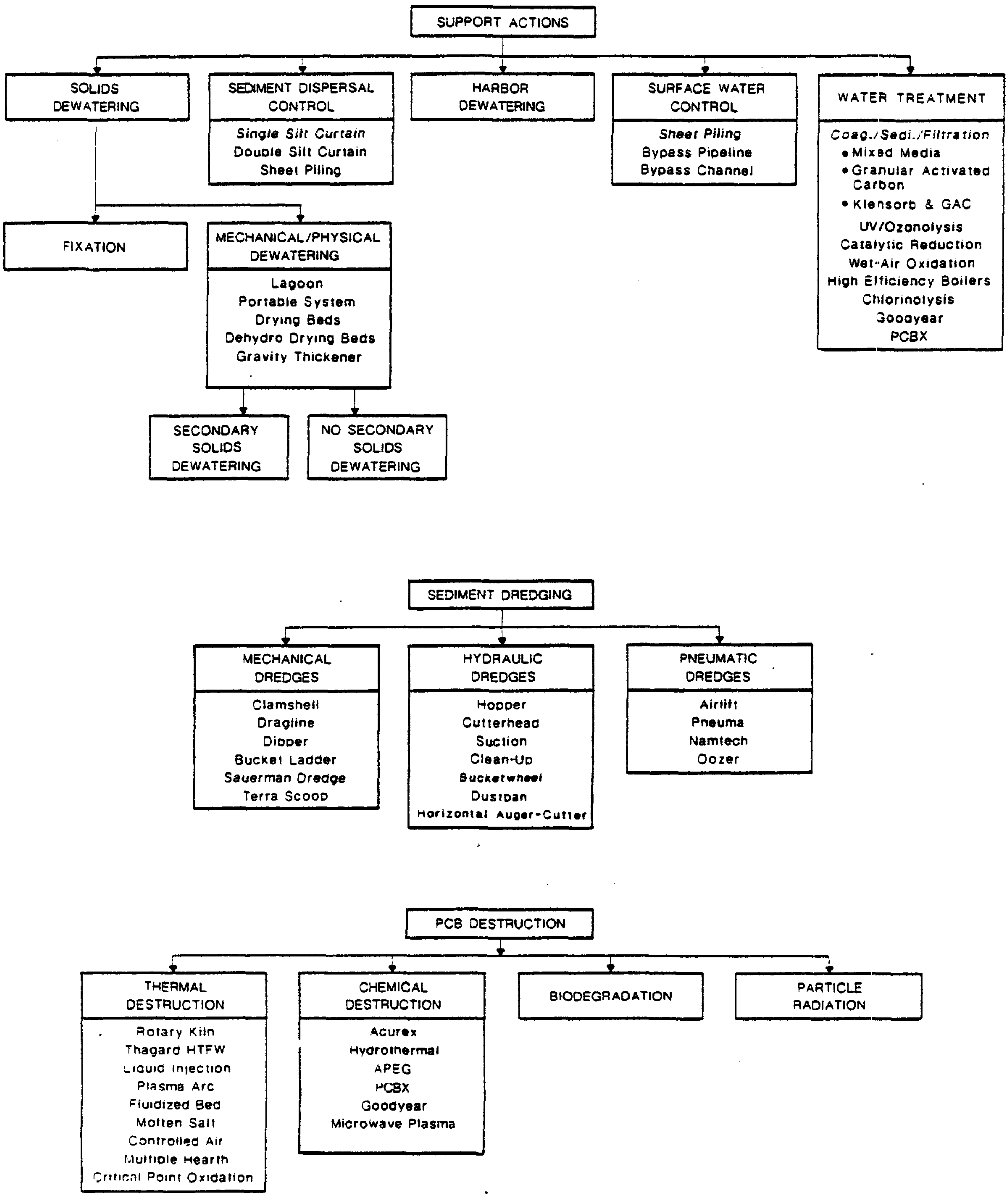
- PCB removal actions that attempt to remediate the problem by taking actions only after the contaminants are removed from the source (i.e., from the estuary bottom). One option is to remove only the PCBs from the sediments using separation technologies, followed either by direct disposal in a controlled environment or by a PCB-destruction process. The available destruction processes include thermal destruction, chemical destruction, biodegradation, and particle radiation (Figure 4-2). The other type of removal action is to physically remove the contaminated sediments by excavation or dredging. Following removal, the sediments either can be directly disposed into a controlled environment, or can undergo various actions prior to disposal. The latter actions include PCB extraction followed by direct disposal or destruction, or a direct destruction of PCBs in the sediments. In either case, the treated sediments allow more flexibility in the disposal options, including their potential placement back into the estuary.

In addition to these remedial action technologies, several types of necessary support actions also had to be identified and evaluated. These include solids dewatering by either fixation or mechanical/physical processes, sediment dispersal control, harbor dewatering, surface water control, and water treatment. The individual technologies available for these support actions are identified in Figure 4-2.

4.3 Results of Initial Screening

As implied in previous sections, the intent of this initial screening process was to eliminate technologies from further consideration based solely on critical limitations of the individual technologies themselves. No attempt was made in this phase of the study to comparatively evaluate technologies in order to retain only the most cost-effective technologies.

The identification and screening of technologies was based on an extensive review of the available literature; previous work completed at other PCB sites; direct



TECHNOLOGIES/ALTERNATIVES IDENTIFIED
FOR PRELIMINARY SCREENING PROCESS
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

FIGURE 4-2

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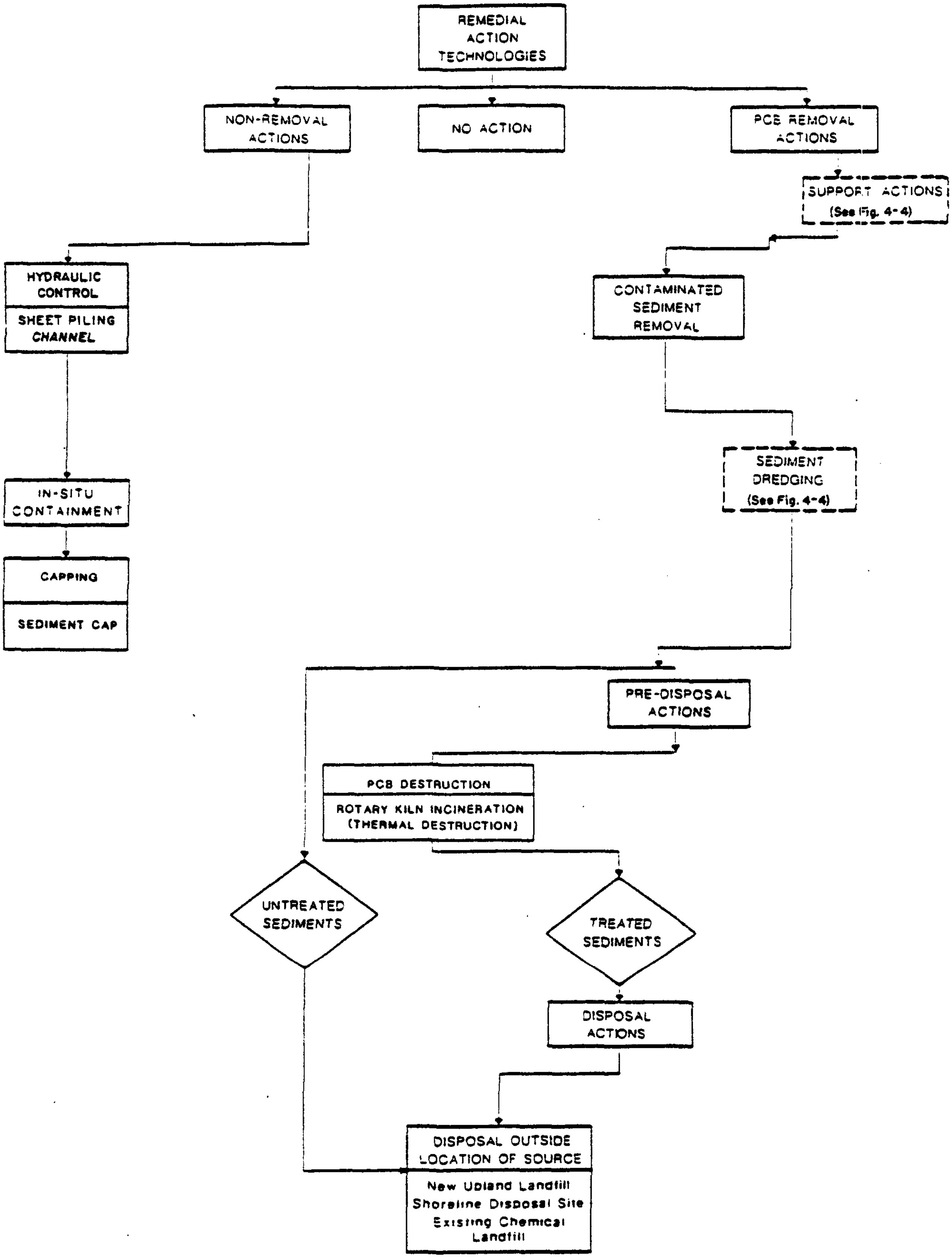
contacts with process developers, manufacturers, etc.; meetings with EPA, State, and local officials; site visits; and discussions with experts in related disciplines. Upon completion, the findings of this initial screening were reviewed by the EPA and the Interagency Task Force. The resulting comments and suggestions have been incorporated into this document.

The results of this initial screening process are summarized in Figures 4-3 and 4-4, which mirror Figures 4-1 and 4-2 with the exception that only those technologies deemed suitable for further study are shown. The supporting information for the initial screening is contained in Appendix B. In the appendix, a fact sheet is provided for each technology that includes a statement of purpose, the operational principles, a summary description, a statement as to its technological status, and a recommended course of action.

Elimination of Technologies ?

Even though each general category of alternative (no action, nonremoval actions, and PCB removal actions) was retained, more than 60 percent of the individual options and technologies were eliminated in the initial screening process. All in-situ treatment technologies and PCB separation, removal, and extraction technologies were eliminated because they are still in the developmental or laboratory/pilot-scale stage and have not been demonstrated for the intended application. All but one of the PCB destruction technologies were eliminated either for the same reason or because they are not applicable to PCBs bound in a sediment matrix. The excavation options (dredging is not included in this category) for sediment removal were ruled out because the thick, unconsolidated sediment deposits will not provide adequate bearing support for equipment unless very costly support actions are implemented. Harbor dewatering would also be necessary, but was deemed inappropriate for technical reasons. The use of a pipeline to convey the Acushnet River as a surface water control measure was found to be technically infeasible. Other individual technologies were also eliminated for various reasons, as discussed in Appendix B.

The potential remedial action alternatives and technologies that remain for consideration in the second phase of screening are summarized as follows:



TECHNOLOGIES/ALTERNATIVES REMAINING AFTER PRELIMINARY SCREENING PROCESS
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

FIGURE 4-3

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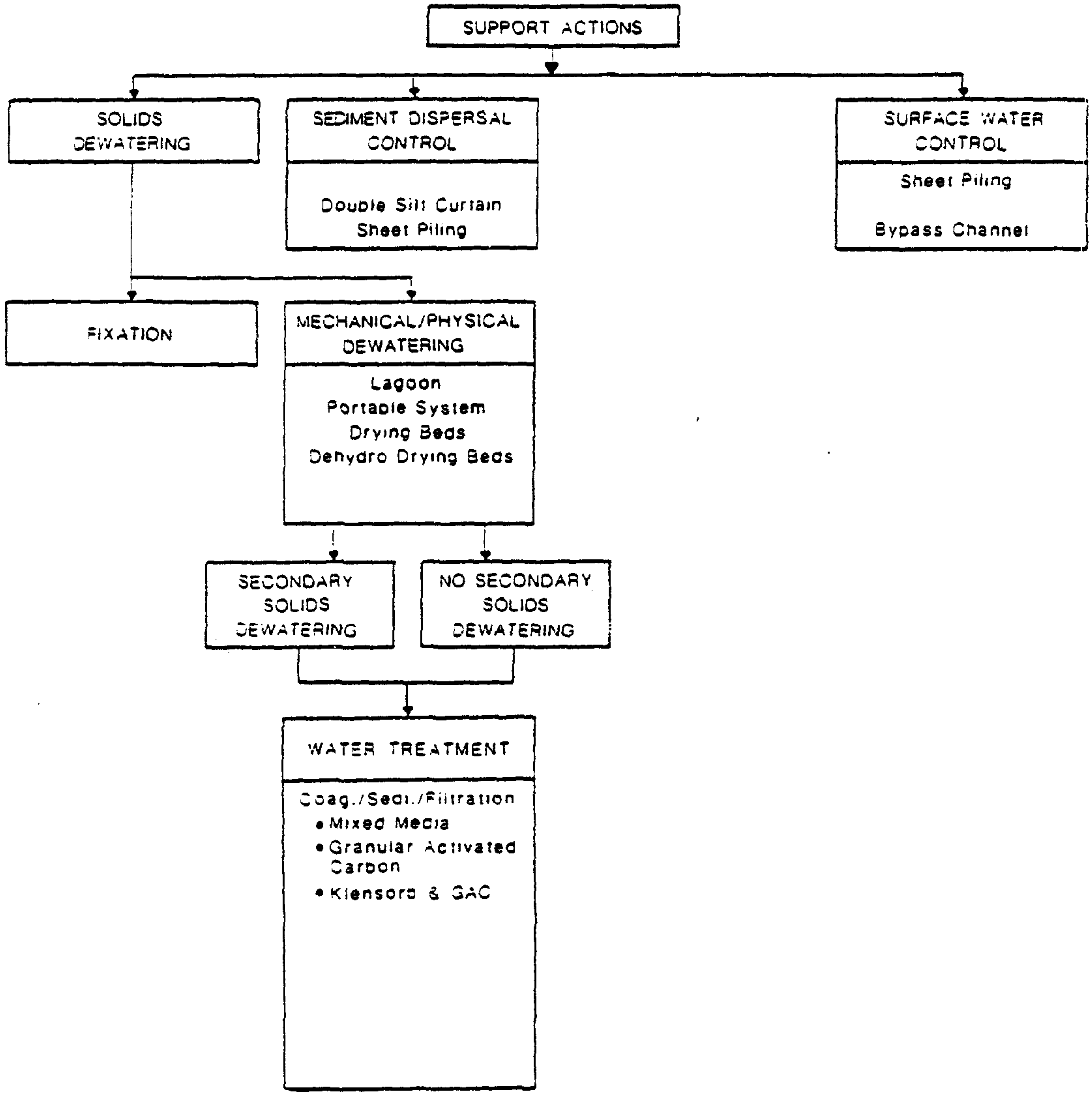

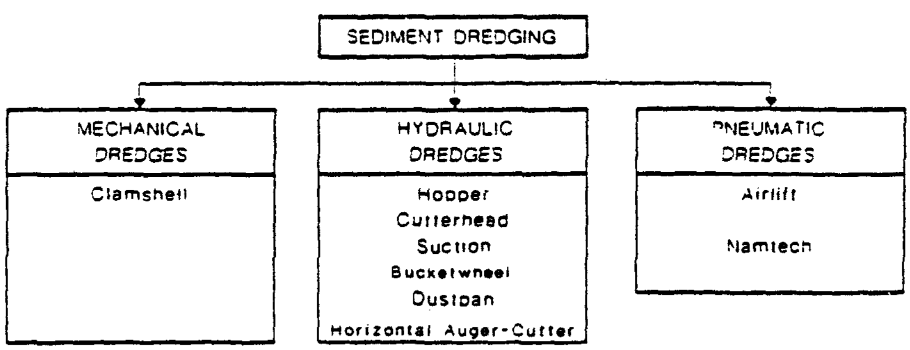

TECHNOLOGIES/ALTERNATIVES REMAINING
AFTER PRELIMINARY SCREENING PROCESS
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

FIGURE 4-4

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- *No-Action Alternative:*

- Non-Removal Actions: Hydraulic control using sheet piling or a bypass channel, in conjunction with in-situ containment of the contaminated sediments.

- PCB Removal Actions: Contaminated sediment removal by dredging, with direct disposal or incineration before disposal into an upland landfill, a shoreline disposal site, or an existing, out-of-state chemical landfill.

- Support Actions: A reduced number of technologies for solids dewatering, sediment dispersal control, surface water control, and water treatment.

5.0 SECONDARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES

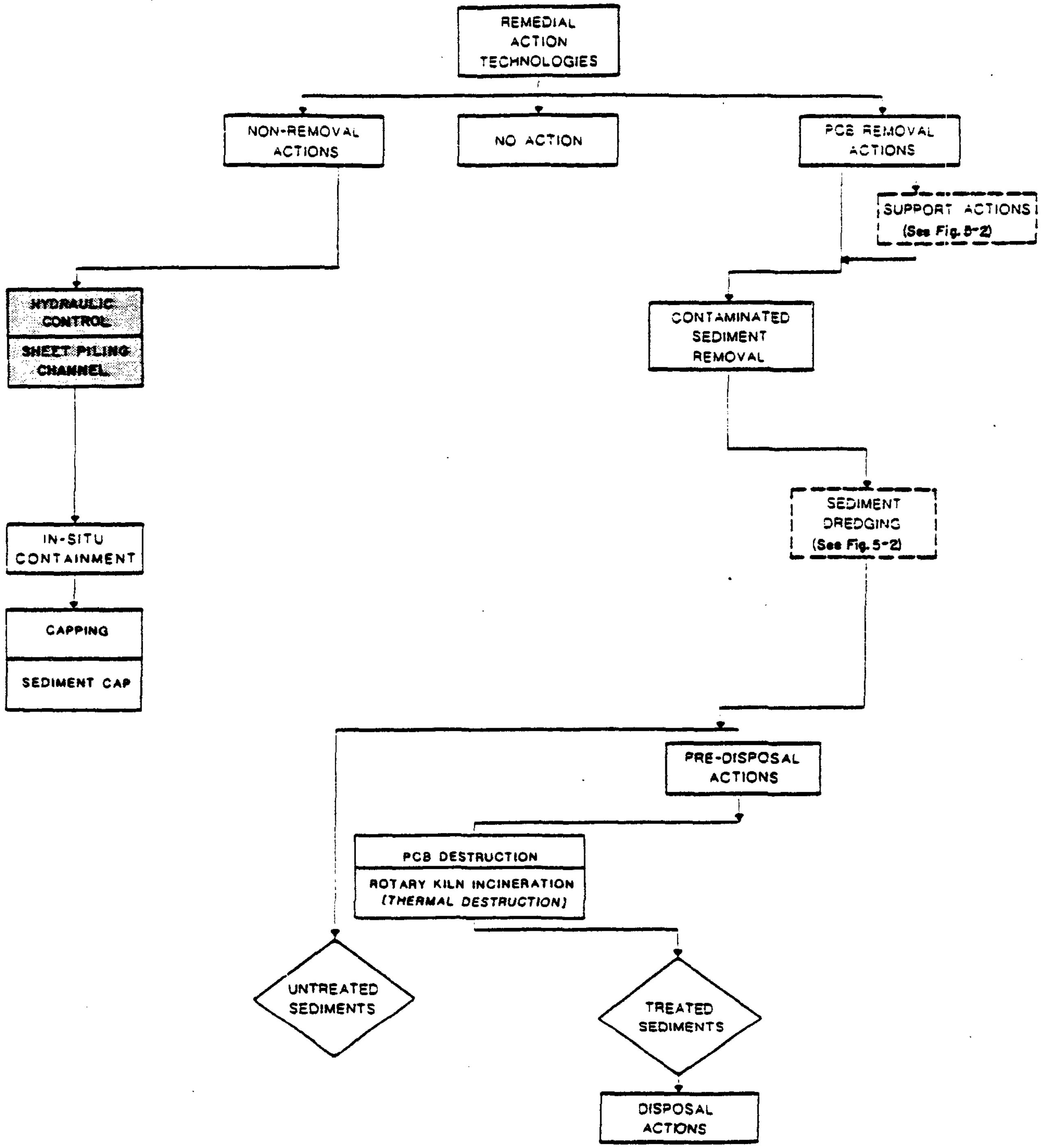
5.1 Objective

The initial screening of remedial action technologies presented in Section 4.0 determined which of the individual technologies were both consistent with the *National Contingency Plan* and appropriate to the problems and constraints of the hot-spot areas. No consideration was given to a comparative evaluation of the technologies to determine the "most appropriate" among them. In this section, a second level of screening is performed on the remaining technologies toward the objective of selecting only the most cost-effective technology in each grouping that provides adequate protection. This will enable the subsequent development and evaluation of remedial action alternatives to proceed with a reasonable number of the most feasible technology combinations.

5.2 Screening Procedure

The remedial action technologies that remained after the initial screening are reproduced in Figures 5-1 and 5-2. Also noted in the figure (shaded boxes) are the groupings of technologies that will undergo a comparative screening in this section. These include hydraulic control, solids dewatering, sediment dispersal, and sediment dredging technologies. It is these groupings that still include more than one technology option and for which a comparative screening can be used to eliminate all but one technology for further consideration.

Other groupings have already been reduced to a single technology in the initial screening phase and need not be considered in the secondary screening. These include the in-situ containment by sediment capping, PCB destruction by rotary kiln incineration, and water treatment using a coagulation/sedimentation/filtration process. The latter grouping actually includes three specific processes as a subgrouping, but each represents a commercial variation of the general process category and a final selection must await treatability studies. Secondary dewatering will also be retained without a second level of screening. Its potential



TECHNOLOGIES/ALTERNATIVES SELECTED FOR SECONDARY SCREENING PROCESS
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

FIGURE 5-1

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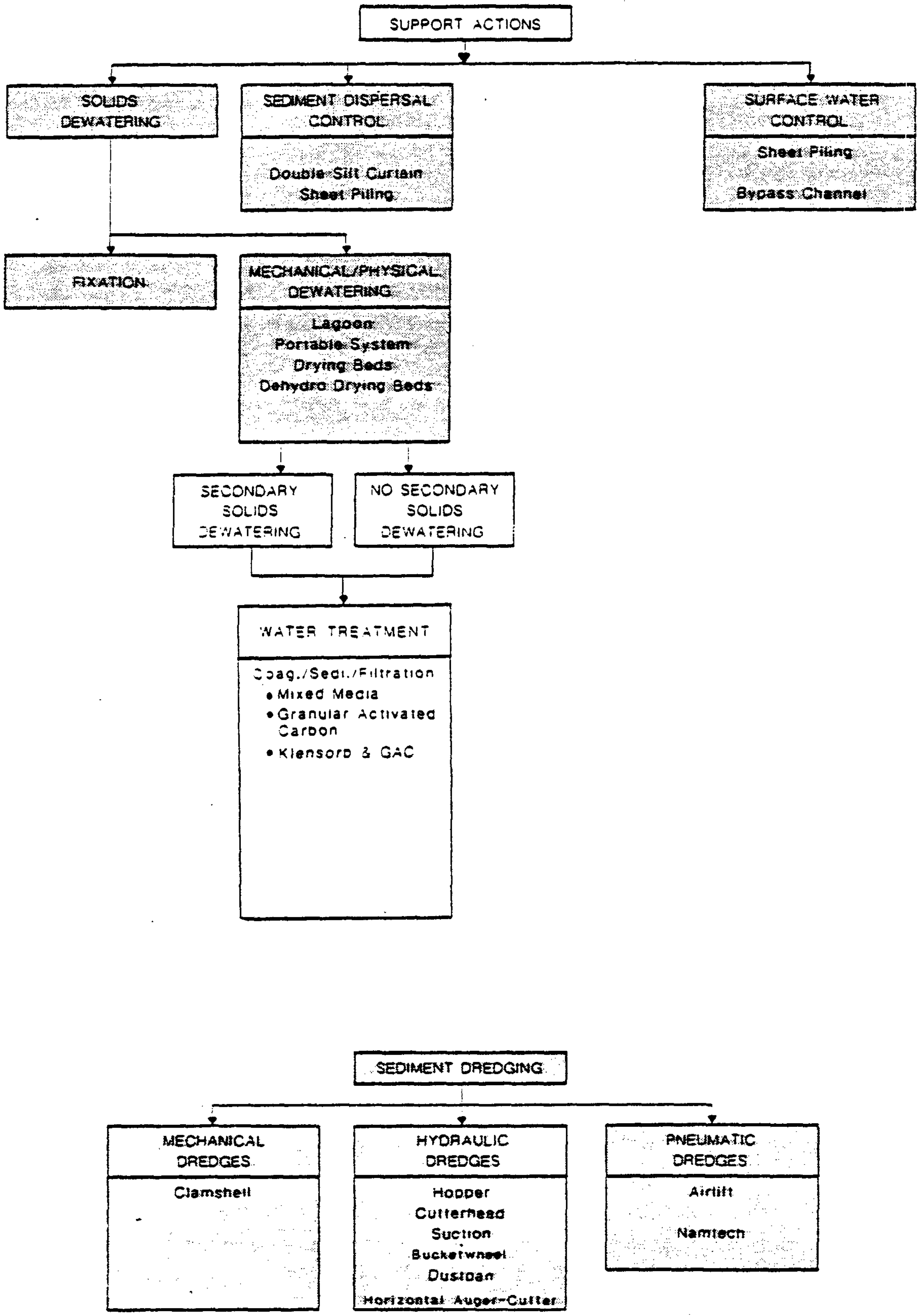

TECHNOLOGIES/ALTERNATIVES SELECTED FOR SECONDARY SCREENING PROCESS
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

FIGURE 5-2

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use is limited to a support activity for the options of incineration or hauling to an existing chemical landfill.

Exceptions to the above scenario are the three options available for disposal of the dredged sediments. Because of the many policy, regulatory, and environmental constraints potentially affecting the ultimate recommendation of an upland disposal site versus an in-harbor disposal site, each was retained for further analysis in the development and evaluation of remedial action alternatives. The use of an existing chemical landfill will also be considered in later sections as an option for disposal of very highly contaminated sediments.

In this section, conclusions and recommendations of the secondary screening are presented for the four technology groupings being considered. Details of the screening process, including comparative evaluations of the individual technologies in relation to general screening criteria, are provided in Appendix C. It must be recognized that the information presented in this section and the related appendix is for screening purposes, and is not a detailed presentation of the proposed design features and limitations. Such information is developed in Section 7.0 for those technologies that are integrated into the final remedial action alternatives.

5.3 Hydraulic Control

The two options being compared for hydraulic control are the construction of a channel by driving two parallel rows of marine sheet piling into the harbor bottom, and the construction of an earthen and rockfill channel. The criteria used in the screening process include technical feasibility, implementation factors, and potential impacts.

Based on currently available data on sediment properties and other site conditions, both the sheet piling channel and the earthen channel are judged to be technically feasible. Sheet piling has been used successfully in other parts of the harbor, while earthen channels represent general engineering practice and any design constraints can be typically overcome. The design life of an earthen channel is likely to exceed that of a channel constructed of sheet pile walls, and the maintenance requirements should also be less for the earthen channel.

The construction cost for the earthen channel has been estimated to be about half of the cost of the sheet piling channel. The cost of the sheet piling channel would increase significantly if large debris or boulders are present in the shallow portions of the upper estuary, or if the material specifications must be upgraded if the sheet piling must also serve as a retaining wall for an in-harbor disposal site. Also, sheet pile walls could not easily accommodate existing storm sewer outfalls and would interfere with buried utilities on the harbor bottom. A critical issue that would affect the cost of an earthen channel is the bearing capacity of the underlying sediments, but the results of previous tests related to a major fill project in the lower harbor indicate that the proposed sandfill mat foundation should create a satisfactory support condition.

Each option has general construction problems due to the water-based construction and the presence of highly contaminated sediments along the proposed alignment. However, construction techniques are available to deal with these constraints. Construction of the sheet pile channel is expected to take slightly less time than construction of the earthen channel, but the slight difference in construction time is not considered to be a significant selection factor. The regulatory constraints and impacts of the two options are likewise not significantly different.

Based on the findings of the screening process, an earthen and rockfill channel is determined to be the most effective and practical means of conveying the Acushnet River flows to bypass the hot-spot areas.

5.4 Solids Dewatering

The technologies available for dewatering the dredged sediment are of two general types: 1) a fixation or solidification process in which the excess water reacts with flyash and lime to form a stable, cement-like product; and 2) dewatering processes that utilize gravity settling of particles in combination with other physical and mechanical means to densify the material and remove the excess water. The latter processes include simple settling lagoons, in which water is removed by evaporation and/or surface decant systems; drying beds, which are a variation of a lagoon with a subsurface piping network that provides free drainage at the base of the dredged material; and dehydro-drying beds which are similar to drying beds except that vacuum assistance is provided to augment the drainage system. The portable dewatering system uses a more advanced series of clarifiers and hydroclone separators to achieve solids separation and removal.

There is a limited amount of area available for installing the dewatering equipment. The area surrounding the harbor is heavily industrialized and populated leaving little shoreline open for sediment processing. Areas that are available for use are either wetlands or shallow water inlets (coves). Any dewatering process selected for use should require as little area as possible. The solids content that can be achieved by a given process is also an important factor in order to minimize disposal requirements and to facilitate subsequent handling, treatment, and covering operations. A particle size analysis will be required to determine the technical efficacy of any dewatering process.

The fixation or solidification of sediments does not appear to be the most feasible alternative for the case under study. Dewatering by this method is achieved by the addition of materials which greatly increase the volume of materials to be disposed. This method has not been proven effective for materials containing levels of organics that are likely to be present in the Acushnet River Estuary. Costs would also be very high for this alternative in comparison to the other dewatering methods. Other critical limitations of fixation are the potential shortage of flyash sources in the region, and the community and potential public health impacts of the increased truck traffic for flyash and lime delivery.

A report on pilot-scale testing of the portable sediment dewatering system indicates that this system is inadequate for the desired use. The cost is relatively low, but the desired solids content will not be achieved at the design rate of loading. Sediments would require temporary storage in a lagoon, and the separated solids would require an additional dewatering step if performance results equivalent to those of the other options are to be achieved.

The use of either lagoons or drying beds (with or without vacuum assistance) is technically feasible and could be implemented without severe constraints. The relative land requirements are similar, since the increased consolidation of the dewatered sediments achieved by the underdrain systems is offset by the suggested use of thinner lifts in drying beds. Other factors, such as regulatory constraints and environmental and community impacts, are also similar for the various options.

The screening of these technologies, therefore, centers on whether the increased solids content achievable through the use of underdrains and vacuum equipment warrants the additional capital, operation, and maintenance costs. From a technical standpoint, the general nature of the sediments (silty sands, glacial outwash) indicates that lagoons will provide sufficient settling capacity and that additional physical/mechanical dewatering devices are not necessary. Even the small clay fraction is expected to settle out within the residence time of the lagoon, due to the high salinity of the estuarine waters. The anticipated treatment of the decant water further eliminates the risk associated with any organic or clay fractions that do wash out of the lagoon. In summary, the percent solids produced by simple settling in a lagoon is sufficient for disposal purposes. Secondary dewatering will be necessary for certain alternatives regardless of which technology is chosen.

The additional costs associated with drying beds are small when compared to the total estimated cost of the overall remedial action alternatives, and one could argue that drying beds should be implemented to optimize the dewatering capability of the system. However, the lagoon dewatering system is judged to be sufficiently effective in achieving the dewatering objectives, and the additional expenditures and operation/maintenance requirements of drying beds do not warrant further consideration of this technology.

5.5 Sediment Dispersal Control

Even though both sheet piling and double silt curtains are considered to be sediment dispersal control technologies, their principal technological purpose differs. Sheet piling can be used to prevent the hydraulic transport of bedload and near-bottom sediments and to impound water to promote the settling of suspended solids. However, sediment transport can still take place over the top of the piling under weir flow conditions. The suspended sediment in the upper water column is effectively contained by silt curtains. However, since a silt curtain must be maintained at least 2 feet above the harbor bottom, contaminated sediments could pass beneath the curtain. As a result, the selection of sheet piling or silt curtains as sediment dispersal controls is dependent on the intended use within the framework of remedial action alternatives.

Both sheet piling and silt curtains are expected to be useful in the proposed alternatives for hot-spot remediation. Sheet piling is recommended for use in the construction of a weir to enclose the opening of the Coggeshall Street Bridge. Such a weir would prevent the transport of bedload and near-bottom sediments to the lower harbor and would serve as a final sediment trap for any construction-related sediment release during the implementation of a selected remedial action. The impoundment created by the structure would reduce flow velocities near the channel bottom where a concomitant reduction in shear forces will also lessen sediment resuspension. Tidal and freshwater flows would be able to pass over the weir structure. The intent is for this structure to be temporary since any other remedial action would negate the need for downstream sediment dispersal control. No other use of sheet piling for purposes of sediment dispersal control is anticipated.

Double silt curtains are recommended for use in two ways. First, in conjunction with the aforementioned sheet piling to reduce the suspended sediment load over the weir. The silt curtain would be suspended parallel to the sheet pile weir at a sufficient distance upstream from the weir to be outside the zone of velocity increases over the weir. Suspended sediments in the upper water column would be blocked by the silt curtain and would settle, with subsequent entrapment behind the sheet piling. The second use is as a local sediment dispersal control measure during construction operations. Although it has been generally concluded that resettling of most sediments will take place in the immediate vicinity of dredging or other operations, the silt curtain will provide a physical barrier to any fine-grained or organic materials that are resuspended. Fabrics have been developed that will control sediments in the 0.5 mm and smaller particle size range. The attachment of an absorbent material to the silt curtain would hinder the dispersal of any oily films that may be generated during dredging operations and other construction activities. High levels of PCB contamination are likely to be associated with the oily films.

5.6 Sediment Dredging

Previous studies of alternatives for the remediation of contaminants in the New Bedford Harbor concluded that dredging of the contaminated sediments is the only feasible alternative available. Most of the remedial action alternatives developed in this study involve dredging. This central importance of dredging from a technical standpoint is underscored by the related public health and environmental concerns. The reason for these concerns is that any activity that disturbs and resuspends the sediments could accelerate the release of PCBs and metals to the environment and downstream areas. ← #!!

In response to these concerns, a thorough literature review of existing technologies and dredging research programs was conducted as part of this investigation. The effort was directed toward the most recent technological advances in the following: reduction of material resuspension; decreased environmental harm; higher production efficiencies; and greater precision, accuracy, and control over the dredging process.

Added to these factors are the selection criteria imposed by local site conditions, and the need to concurrently consider the compatability of all components of the dredging operation (excavation, transportation, treatment, and disposal) as a total integrated system and not as separate components. Particular criteria include the following:

- The need for a land-based mobilization or the use of a small dredge due to a clearance of only 6-10 feet (depending on the tide) at the Coggeshall Street Bridge.

- The production rate to dredge approximately 1 million cubic yards (CY) of sediments within a 2-year project period.

- The compatability of the dredge equipment with the variable type of material (silts, sands, clay, gravel, possibly boulders and other debris) to be dredged.

- The need to dredge a minimum of 3 feet of sediment in water ranging in depth from zero at low tide to approximately 20 feet in the deep, central channel.

- The desire to maximize slurry density in order to expedite solids dewatering and to reduce the amount of decant water for treatment.

Based on the secondary screening of available dredging technologies (as reported in Appendix C), the hydraulic pipeline or "cutterhead" dredge was selected for subsequent incorporation into the remedial action alternatives. Three types of cutterhead dredges are available, including the rotary, bucketwheel, and horizontal auger dredges. The final recommendation was the bucketwheel type with the capability to recirculate slurry water.

The selection of the cutterhead dredge was based on the following:

- Mobilization: The cutterhead dredge can be shipped overland and assembled on site.

- Production Rate: The cutterhead dredge is capable of excavating 1 million CY of sediment in a 2-year period.

- Recirculation of Slurry Water: The cutterhead dredge can recirculate slurry water, thereby realizing considerable savings by avoiding State and Federal regulations that require treatment of slurry water prior to discharge.

- Denser Slurries: The cutterhead dredge can produce denser slurries than other dredging equipment, which is particularly important given the limited treatment, dewatering, and disposal space available.

- Navigability: The cutterhead dredge can be maneuvered in the estuary and can operate in shallow or deep areas.

- Sediment Dispersion: The resuspension of sediments due to cutterhead dredging is rated as average when compared with other types of dredges. Elevated levels of suspended material are generally localized in the immediate vicinity of the cutter.

Upon completion of the analysis of dredging technologies, a meeting was held with U.S. Army Corps of Engineers personnel at the Waterways Experiment Station in Vicksburg, Mississippi. This group has several ongoing research projects related to the dredging of contaminated sediments, and are considered to be leading experts in this subject. A general conclusion of the meeting was that the problems encountered in the Acushnet River Estuary are not irreconcilable with the current state-of-the-art in dredging, and the local conditions (sediment types, PCB properties, anoxic saline conditions, etc.) will not involve a singularly high-risk dredging operation. The selection of a cutterhead dredge was deemed to be appropriate within the framework of the available data base.

A specific issue raised at the meeting was the appropriateness of recent technological advances in dredging equipment made by the Japanese to minimize sediment resuspension and dispersal. These technologies had been eliminated in the initial screening due to perceived restrictions imposed by the Jones Act, which regulates the use of foreign vessels and equipment in the United States. Concerns were subsequently raised when it was determined that the Jones Act would not restrict the use of dredging technologies developed in Japan. The Corps personnel concluded that more readily available equipment can satisfy the study requirements, however, and that the Japanese equipment is only a critical need if sediment dispersal control even in the immediate vicinity of the dredge is an issue. Further, these dredges are primarily for use when extremely fine-grained sediments are involved and may not be capable of operating in a glacial outwash area due to the possible presence of gravel, boulders, and various other debris.

6.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

6.1 Objective

The screening processes presented in Sections 4.0 and 5.0 have focused on the applicability and comparative value of individual remedial technologies. None of these technologies singularly represents a remedial action alternative for the hot-spot areas. The objective of this section is to develop complete, meaningful, and implementable alternatives for remediation of the hot-spot areas that are consistent with the study objectives put forth in Section 1.2.

6.2 Initial Development of Remedial Action Alternatives

Within the framework of the phased study approach, a remedial action alternative is developed as a combination of individual technologies, including support actions, that remained after the secondary screening. The number of combinations that could theoretically be developed under this general definition greatly exceeds 100, which would create an impractical evaluation task. However, upon closer examination, many potential combinations include technologies that are not technically compatible or would introduce a redundant or "overkill" situation. An example of the former would be to incorporate incineration without a dewatering step, while an example of the latter would be to construct a hydraulic control channel and then to remove all the contaminated sediments to an existing chemical landfill. Other alternative combinations can be excluded from consideration due to a critical shortcoming with respect to the cost-effectiveness measures described below. For example, to incinerate all the contaminated sediments or to transport them to an existing chemical landfill would cost in excess of $100 million and may be prohibitively expensive. Incineration of all sediments would likewise take up to 20 years to complete, which is unacceptable from a "time to implement" standpoint.

The selected combinations and options represent the results of a progressive evaluation procedure, and reflect considerable communication with and input from the EPA and other Federal, State, and local officials. Numerous other combinations and variations thereof were evaluated in the course of this study. Of particular note are the alternatives previously elucidated by others, as for example the use of the western cove or the North Terminal area as disposal sites. Such alternatives were specifically evaluated and found to be infeasible. (The two disposal sites were found to have insufficient land area and storage volume to satisfy the needs of the alternative.)

Upon completion of the engineering and scientific evaluation of the potential combinations, four basic remedial action alternatives were identified. These are:

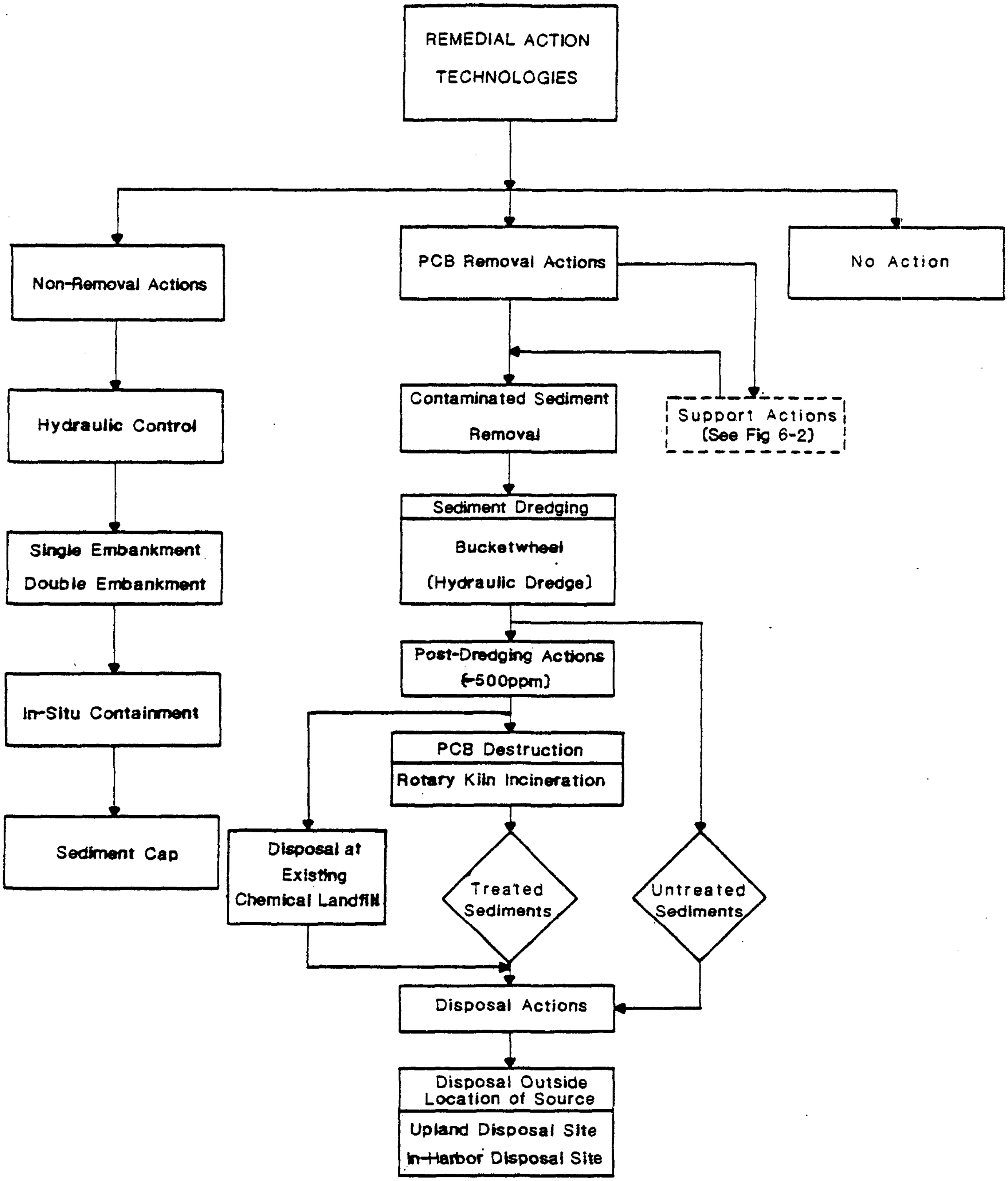
- No action

- Hydraulic control of the Acushnet River freshwater and tidal flows to hydraulically isolate the hot-spot areas, along with a submerged sediment cap to locally isolate the contaminated sediments for public health reasons.

- Dredging of the contaminated sediments combined with closure of part of the upper estuary to be used as a disposal site, including necessary dewatering and water treatment steps.

- Dredging of the contaminated sediments with disposal into a new upland chemical landfill in the New Bedford regional area, including necessary dewatering and water treatment steps.

A summary of these alternatives is provided in Figure 6-1. A detailed description of each is presented in Section 7.0. As indicated in Figure 6-1, the two dredging alternatives include three optional actions prior to the disposal of the most highly contaminated sediments (> 500 ppm PCBs). These are the direct disposal of all dredged sediments into the respective in-harbor or upland disposal site (i.e, no post-dredging action), the incineration of the PCBs in the highly contaminated sediments prior to disposal, and the removal of the highly contaminated sediments



TECHNOLOGIES/ALTERNATIVES REMAINING AFTER SECONDARY SCREENING PROCESS NEW BEDFORD HARBOR FEASIBILITY STUDY NEW BEDFORD, MA

FIGURE 6-1

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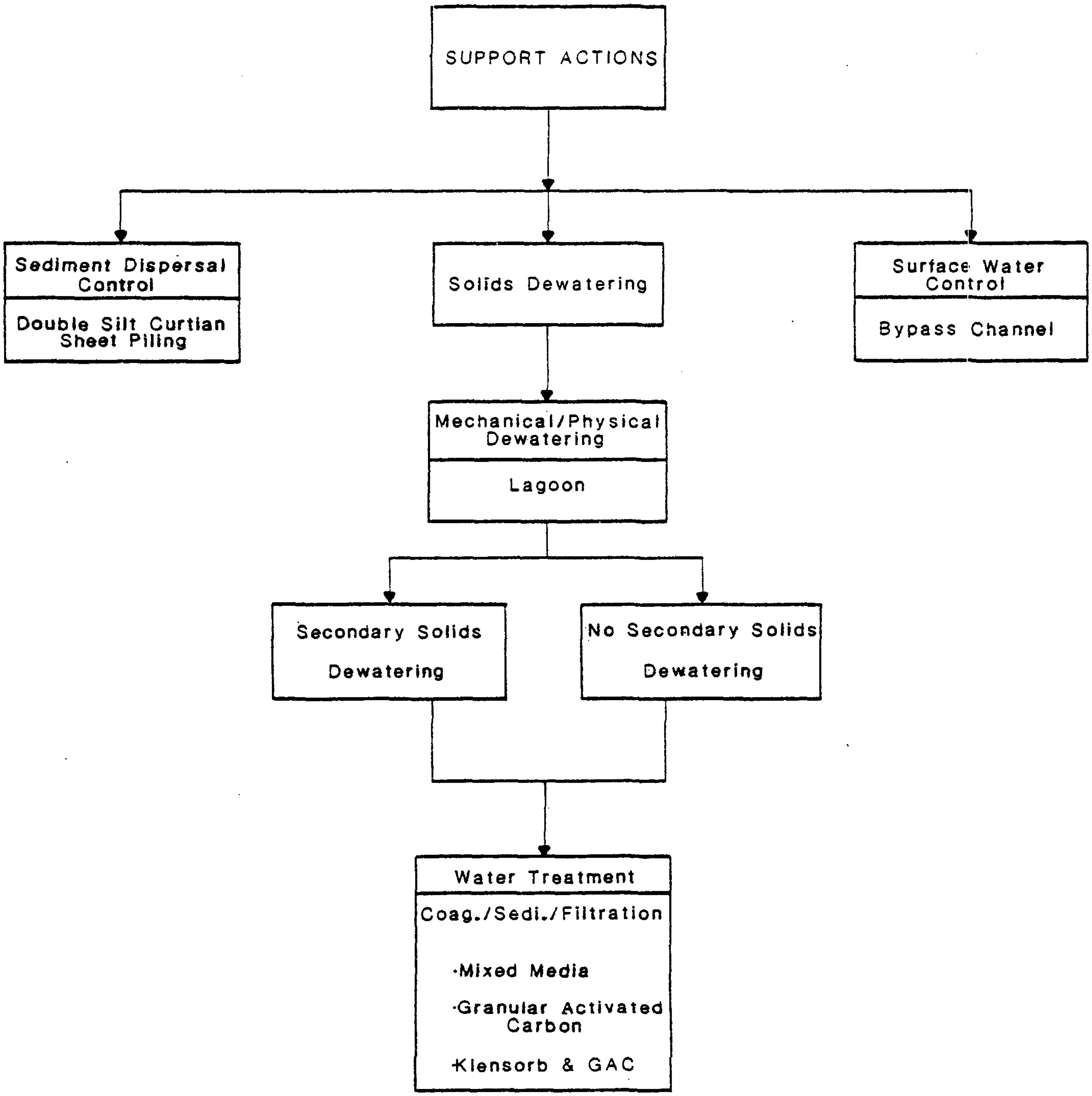

TECHNOLOGIES/ALTERNATIVES REMAINING AFTER SECONDARY SCREENING PROCESS
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

FIGURE 6-1 (cont.)

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to an existing chemical landfill (e.g., the CECOS facility in New York). A cost-effectiveness analysis of these options is straightforward and independent of the choice of either an in-harbor or upland site. An evaluation and selection of the most cost-effective of these options will be made in this section prior to the final evaluation of the overall remedial action alternatives in Section 8.0.

Two additional options exist for the in-harbor disposal of contaminated dredge material. The first is whether lining the bottom of the disposal site is necessary and cost-effective relative to simply placing the dredged sediments onto the existing harbor bottom. This option will be at least partially influenced by policy and regulatory decisions, and thus both the lined and partially lined alternatives will be retained for a detailed cost-effectiveness evaluation in Section 8.0. The other option is whether the disposal area should be developed simply by closing off a portion of the harbor using a single embankment or whether a channel (i.e., a double embankment) should be constructed to effect a more positive control on local flow conditions. As with the post-dredging option, the evaluation and selection of a single versus double embankment is straightforward and will be completed in this section. Note that this option only pertains to the dredging and in-harbor disposal alternative. A double embankment channel will be retained for the hydraulic control alternative since flow control is critical and the downstream end of the channel must be located near the center of the estuary to tie into the opening at the Coggeshall Street Bridge.

Prior to an evaluation of these options in Section 6.5, a series of effectiveness measures and cost measures will be developed. These measures were used as the principal evaluation criteria in this and subsequent evaluations.

6.3 Effectiveness Measures

Whether a remedial action achieves its stated objectives depends in large part on the technical feasibility of the action. In addition, the reduction of health effects and environmental impacts, institutional constraints, and public acceptability must also be considered when judging the effectiveness of an action. Based on these concerns, a set of independent "effectiveness measures" were developed as follows:

- Technology Status
- Risk and Effect of Failure
- Level of Cleanup/Isolation Achievable
- Ability to Minimize Community Impacts
- *Ability to Mitigate Effects on Public Health, Welfare, and the* Environment
- Time Required to Achieve Cleanup/Isolation
- Commercial Impacts
- Acceptability of Land and Water Use After Action

These eight effectiveness measures are defined as follows for the hot-spot areas.

Technology Status

Technologies involved in a remedial alternative are either proven, widely used, or experimental when applied to uncontrolled hazardous waste sites. Generally, a proven and widely used technology is to be rated highest, and experimental technologies lower. *For some specific pollution problems, the only technology* available for use at uncontrolled sites may be in the experimental stage. In such a case, an experimental technology may be chosen as cost-effective if it is highly rated with respect to the other effectiveness measures. Because proven and widely used technologies are available for remediation of the hot-spots, and experimental technologies have been previously eliminated in the screening process, this criterion will not be evaluated further for each individual alternative.

Risk and Effect of Failure

The risk factor is used to assess the potential of failure of the remedial action to achieve its stated objectives and the overall consequences of such a failure. A high risk is associated with high potential for failure and significant impacts. Alternatives with a low potential for failure and relatively minor potential impacts resulting from failure are considered low-risk alternatives. The public's perception of the risk and effects of failure must also be considered, since this could play a role in the eventual acceptance or rejection of the action.

Level of Cleanup/Isolation Achievable

This factor attempts to evaluate how "clean" the site will be after the remedial action is implemented. The levels of cleanup achievable range from "no action" to complete excavation and removal or encapsulation of wastes. For purposes of this study, cleanup implies that pollutants are removed from the site and/or the environment by the remedial action alternative, whereas isolation means that the transport of pollutants from the site to the environment is stopped or slowed.

Ability to Minimize Community Impacts

A community impact is broadly defined as any change in the normal way of life which can be directly or indirectly attributed to the execution of the remedial action. These changes include increased noise during the action, traffic congestion, loss of access to the site or to roads near the site, decline in property values, and stress related to all of the above and to uncertainty about health risks. Also included are actions that people would not normally undertake, such as moving permanently from a condemned property or moving to temporary lodging during the remedial action.

Ability to Mitigate Effects on Public Health, Welfare, and the Environment

This measure compares the remedial alternatives in terms of how well they attain relevant public health and environmental standards or criteria, such as those under the Safe Drinking Water Act, Clean Water Act, or Clean Air Act, both during and after the implementation of the remedial alternative. Alternatives will be compared on level of attainment rather than just attainment or non-attainment. In addition, the alternatives will be evaluated on their ability to effectively mitigate and minimize damage and provide adequate protection of public health, welfare, and the environment.

Time Required to Achieve Cleanup/Isolation

The time required for a remedial action alternative to achieve its designed degree of cleanup or isolation may range from months to many years, depending on the technology involved and site conditions. The evaluation of alternatives relative to this factor must consider not only the time required to construct and implement an action, thereby satisfying some objectives (e.g., elimination of the risk of direct contact with contaminants), but also the time necessary to fully satisfy the remaining remedial action goals once the action is implemented (e.g., reduction of contaminant levels in the food chain to target values).

Commercial Impacts

This factor evaluates the impacts of the remedial alternatives on the commercial environment of the harbor area, since the impacts (either positive or negative) of remedial measures performed in the estuary will be felt in the downstream areas. These impacts include the effects of the actions on harbor transportation and the commercial fishing industry in the harbor, both during and after the performance of the remedial action.

Acceptability of Land and Water Use After Action

This factor assesses the remedial actions in terms of achieving the best use of the land and water resources of the site after the action has been completed. Resources that may be affected as a direct result of a remedial action, such as those at a waste disposal site, must also be considered. The best use of the resource is not limited to economic considerations, but must also evaluate the needs of the community as a whole (e.g., parks, greenbelts, recreation, etc.).

6.4 Cost Measures

According to the National Contingency Plan, a total cost estimate for a remedial action must include construction costs and annual operation and maintenance costs.

Direct capital costs may include the following cost components:

- Construction Cost - Components include equipment, labor (including fringe benefits and workman's compensation), and materials required to install a remedial action.
- Equipment Costs - In addition to the construction equipment cost component, remedial action and service equipment should be included.
- Land and Site Development - Costs include land-related expenses associated with purchase of land and development of existing property.
- Buildings and Services - Costs include process and non-process buildings and utility hook-ups.

Indirect capital costs may include the following components:

- Engineering Expenses - Components will include administration, design, construction supervision, drafting, and testing of remedial action alternatives.

- Legal Fees and License/Permit Costs - Components will include administrative and technical costs necessary to retain licenses and permits for facility installation and operation.

- Relocation Expenses - Relocation expenses should include costs for temporary or permanent accommodations for affected nearby residents.

- Start-up and Shake-down Costs - Costs incurred during remedial action start-up for long-term activities should be included.

- Contingency Allowances - Contingency allowances should correlate with the reliability of estimated costs and experience with the remedial action technology.

The operation and maintenance costs may include the following components:

- Operating Labor Costs - Include all wages, salaries, training, overhead, and fringe benefits associated with the labor needed for post-construction operations.

- Maintenance Materials and Labor Costs - Include the costs for labor, parts, and other materials required to perform routine maintenance of facilities and equipment for the remedial alternative.

- Auxiliary Materials and Energy - Include such items as chemicals and electricity needed for treatment plant operations, water and sewer service, and fuel costs.

- Purchased Services - Include such items as sampling costs, laboratory fees, and professional services for which the need can be predicted.

- Disposal Costs - Costs should include transportation and disposal of any waste materials, such as treatment plant residues, generated during remedial operations.

- Administrative Costs - Cover all other O&M costs, including labor-related costs not included under that category.

- Insurance, Taxes, and Licensing Costs - Include such items as liability and sudden and accidental insurance, real estate taxes on purchased land or right-of-way, licensing fees for certain technologies, and permit renewal and reporting costs.

- Maintenance Reserve and Contingency Funds - Represent annual payments into escrow funds to cover anticipated replacement or rebuilding of equipment and any large, unanticipated O&M costs, respectively.

Construction costs and operation and maintenance costs were estimated for each remedial action alternative using the appropriate cost categories stated above. For operating and maintenance costs, a "present-value" analysis was used to convert the annual costs to an equivalent single value. Operation and maintenance costs were considered over a 20 year period; a 10 percent discount rate and 0 percent inflation were assumed.

6.5 Cost-Effectiveness Evaluation of Subalternatives

In this section, the relative cost-effectiveness of each option under consideration is evaluated in relation to the measures developed in Sections 6.3 and 6.4. Because the basic objective of this evaluation is to compare the cost-effectiveness of the subalternatives, only the differences associated with the various options will be presented. The overall development of the cost-effectiveness of the selected options will be completed as part of the evaluation of remedial action alternatives in Section 8.0.

6.5.1 Single Embankment Versus Double Embankment Channel

Description: The double embankment option involves the construction of a pair of parallel embankments between which the freshwater flows of the Acushnet River Estuary will be conveyed from the uppermost portion of the harbor to a point downstream of the proposed in-harbor containment site. The embankments, which will be largely constructed from glacial till, will be founded on a four-foot thick layer of sand fill overlying the fine-grained harbor sediments. Filter fabric will cover the glacial till embankments in order to prohibit the migration of contaminants through the embankments and into the uncontaminated waters of the channel. A protective layer of rockfill will be placed on the embankments and the bottom of the channel. As designed, the western embankment will restrict river flows from the New Bedford shoreline and the eastern embankment will serve as a retaining structure for the in-harbor disposal site. Contaminated sediments will be removed prior to construction.

The single embankment will be constructed similar to the eastern embankment and will simply separate the flows of the Acushnet River Estuary from the proposed in-harbor disposal site. In essence, a channel will be formed using the existing western shoreline as one channel bank and the embankment as the other.

Risk and Effect of Failure: If properly designed and constructed, there would be minimal risk of failure of the channel embankments. A failure of either the eastern embankment of the channel or the single embankment will result in a similar risk. In each case, PCB-contaminated sediments would be potentially released into the harbor environment and would be susceptible to downtream transport. An uncontrolled situation similar to the status quo in the estuary would result. An increased risk of the double embankment is the potential failure of the western embankment. However, preliminary calculations indicate that flood water elevations in the channel would be less than 1 foot above predicted harbor flood elevations under existing conditions. Therefore, a failure of the western embankment would not cause significant additional impacts.

Level of Cleanup/Isolation Achievable: Both options would provide a similar level of cleanup and contaminant isolation. One slight difference is that a small amount of contaminated sediments can be expected to remain in the harbor after dredging, and an additional area containing these residual contaminants would be covered by the double embankment channel.

Ability to Minimize Community Impacts: Any significant community impacts will be common to the two options, both during construction and upon completion. Two impacts associated only with the double embankment are the elimination of additional areas for potential recreation or fishing use, and the fact that access to upstream reaches of the Acushnet River will be limited to the channel itself.

Ability to Mitigate Effects on Public Health, Welfare, and the Environment: Most of the environmental impacts caused by channeling the Acushnet River are common to the construction of a single embankment or a double embankment. However, the impacts of a single embankment on wildlife would be less severe than a double embankment channel. The double embankment channel would be of uniform dimension, eliminating the shallow water and slow velocity areas that provide breeding and feeding areas for aquatic species. The single embankment would only slightly alter the streamflow velocity; thus, breeding and feeding areas would not be as heavily impacted.

Another difference would be associated with discharges to the river. Construction of a double embankment channel would force industries that discharge treated effluent or non-contact process water to the river at the present time to either extend their outfalls to the new channel or pay for treatment at the municipal wastewater treatment plant.

Time Required to Achieve Cleanup/Isolation: If properly scheduled, the time required to construct the double embankment channel is only slightly greater than that required for construction of a single embankment.

Commercial Impacts: Neither embankment option will have direct impacts on commerical usage of the estuary and harbor since the upper harbor is not navigable for large vessels.

Acceptability of Land and Water Use After Action: The channel created by the double embankment will have no future use other than to convey flows. On the other hand, use of a single embankment will retain the channel portion of the harbor for recreation, fishing, and related uses.

Costs: The estimated total cost for the double embankment channel is about twice the estimated cost for the single embankment.

6.5.2 Post-Dredging Actions on >500 ppm Sediments

Description: No Post-Dredging Action - Under this option, sediments having a PCB concentration exceeding 500 ppm will be handled and disposed in the same manner as those having a concentration less than 500 ppm.

Description: Incineration - Under the incineration option, sediments having a PCB concentration greater than 500 ppm will be dredged from the upper harbor. The dredged materials will be placed in a temporary containment site to be constructed at the cove located on the western shore of the upper harbor where primary dewatering will occur. The sediments will be further dewatered via a belt filter press, with the resulting water being treated at a facility to be constructed nearby. The dewatered sediments will then be incinerated in a rotary kiln unit and the residue disposed in either an upland or in-harbor containment site.

Description: Existing Chemical Landfill - The final option of contaminated sediments removal to an existing landfill will be similar to the incineration option up through secondary dewatering. The dewatered sediments will be transported by truck to a railroad loading yard located approximately 1 mile south of the cove, and then by rail to an existing chemical landfill such as the CECOS facility near Niagara Falls, New York.

Risk and Effect of Failure: The risks associated with these options vary considerably. The risk of no post-dredging action is maximized for an upland disposal site since highly contaminated sediments would be transported in an untreated state, and any spillage may contaminate offsite areas and cause a health risk. If proper precautions are observed, the probability of spillage is low. It is also noteworthy that the dredging, temporary storage, and transfer operations will all tend to mix the removed sediments. As a result, it is likely that extremely high in-situ concentrations will be dampened out prior to actual transport.

There is a possibility of failure at the containment site, which would result in contaminant migration to surface waters or groundwater. For a properly constructed containment site, however, the probability of this occurring is low. An associated risk of the direct disposal of high-level PCB waste is the increased potential for long-term migration from the disposal area. The degree of risk is dependent on the disposal option, and would be most significant for a partially lined in-harbor site. The nature of PCBs to be immobilized by sediments offsets this risk, and the vertical and lateral extent of any such migration would be limited.

The risks associated with incineration are an incomplete incineration of PCBs, which could lead to the formation of polychlorinated difurans (PCDFs) or other related compounds, and ineffective flue gas cleanup that could release PCBs (and potential byproducts) and metals to the atmosphere. Proper design and construction of the facility and continuous monitoring of the process would minimize the probability of occurrence.

Spillage during transport is the principal risk associated with removal to an out-of-state landfill.

Level of Cleanup/Isolation Achievable: The level of cleanup will be essentially complete for all three options if the removed sediments are properly disposed. For the incineration process, TSCA requires at least a 99.99 percent destruction efficiency for PCBs.

Ability to Minimize Community Impacts: Even though the types of community impacts vary among options (e.g., increased traffic levels, incinerator noise and potential air releases, and increased barge/rail traffic), the levels of the respective impacts are similar, and no significant differences exist as factors in the selection process.

Ability to Mitigate Effects on Public Health, Welfare, and the Environment: All options would have the same impacts relative to the construction of an in-harbor versus upland disposal site. The major difference concerns the post-dredging action involving incineration, since incinerating contaminated sediments near the harbor will eliminate the hazards associated with transporting them long distances. The removal of the incinerator upon completion will eliminate any visual impacts that would result from leaving a building on site. Stack products must be monitored for the presence of PCBs and metals. If the incinerator operates properly, PCB contaminated fugitive dust will be essentially non-existent.

The use of an existing secure chemical landfill would have beneficial effects on the environment. A well-designed and well-managed facility will prevent or minimize impacts on nearby residents. The adverse impacts are a result of solids removal and transport to the facility. This option would involve greater transport distances than those involved with the other two options, thus exposing more people to a potential leakage, spillage, volatilization or a vehicle accident.

Time Required to Achieve Cleanup/Isolation: No additional time will be required to implement the overall remedial action under the no post-dredging option. The time required for incineration is directly dependent on the number of incinerators employed and is expected to be on the order of 6 years. The minimum time period is approximately twice the implementation time for the overall remedial action, and thus incineration would create a significant delay. Any delay or shutdown would have a critical impact on remediation since dredging to satisfy other implementation needs (e.g., embankment construction) would be slowed or halted. Removal of sediments to an existing chemical landfill can be expected to require approximately 4.5 years for completion, or longer if the available storage at the landfill becomes limited or is allocated among a number of hazardous waste cleanup projects. These times represent actual construction and operation times and may be approximately 25 percent longer to allow for appropriate planning and design, as well as to account for poor weather and logistical difficulties.

Commercial Impacts: Only the option of sediment removal to an existing chemical landfill would have a potential commercial impact since the railroad and railroad yard will be needed for sediment transfer and transport over a long time period. The overall impacts of these demands are not fully known at this time.

Acceptability of Land and Water Use After Action: There will be no significant differences among the options as to the post-action use of land and water resources. The no-action and incineration alternatives will require a larger disposal area since the highly contaminated sediments will not be physically removed from the regional area. The incineration and removal options require the use of an additional area for temporary sediment storage and dewatering.

Costs: Based on the alternative of sediment dredging and the use of a partially lined, in-harbor disposal site, with an estimated cost of $27.8 million with no post-dredging action, the costs of the incineration option and the option of removal to an existing landfill are approximately 2.6 times higher and 3.5 times higher, respectively.

6.6 Selection of Subalternatives

A comparison of the cost-effectiveness measures for the single embankment and double embankment channel for the in-harbor disposal alternative indicates that the single embankment option has a lower cost, requires less time for implementation, and has fewer impacts than the double embankment channel. Each option has been judged to provide a comparable level of cleanup and general effectiveness. For these reasons, the single embankment option has been selected for integration into the in-harbor disposal alternative.

For the post-dredging options, the relatively high cost and time to achieve cleanup/isolation justify the elimination of incineration and sediment removal to an existing chemical landfill. This is particularly valid in this case since no option exhibits exceptional value with respect to the effectiveness measures. Each option involves moderate levels of risk, each has the potential for limited community impacts, and each provides a similar level of clean-up. As a result, the remedial actions evaluated in the next section will assume that dredged sediments will go directly to a dewatering/disposal facility regardless of PCB concentration.

← ?
Disagree
Incineration
vs.
L.F.

7.0 DETAILED DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

7.1 Objectives

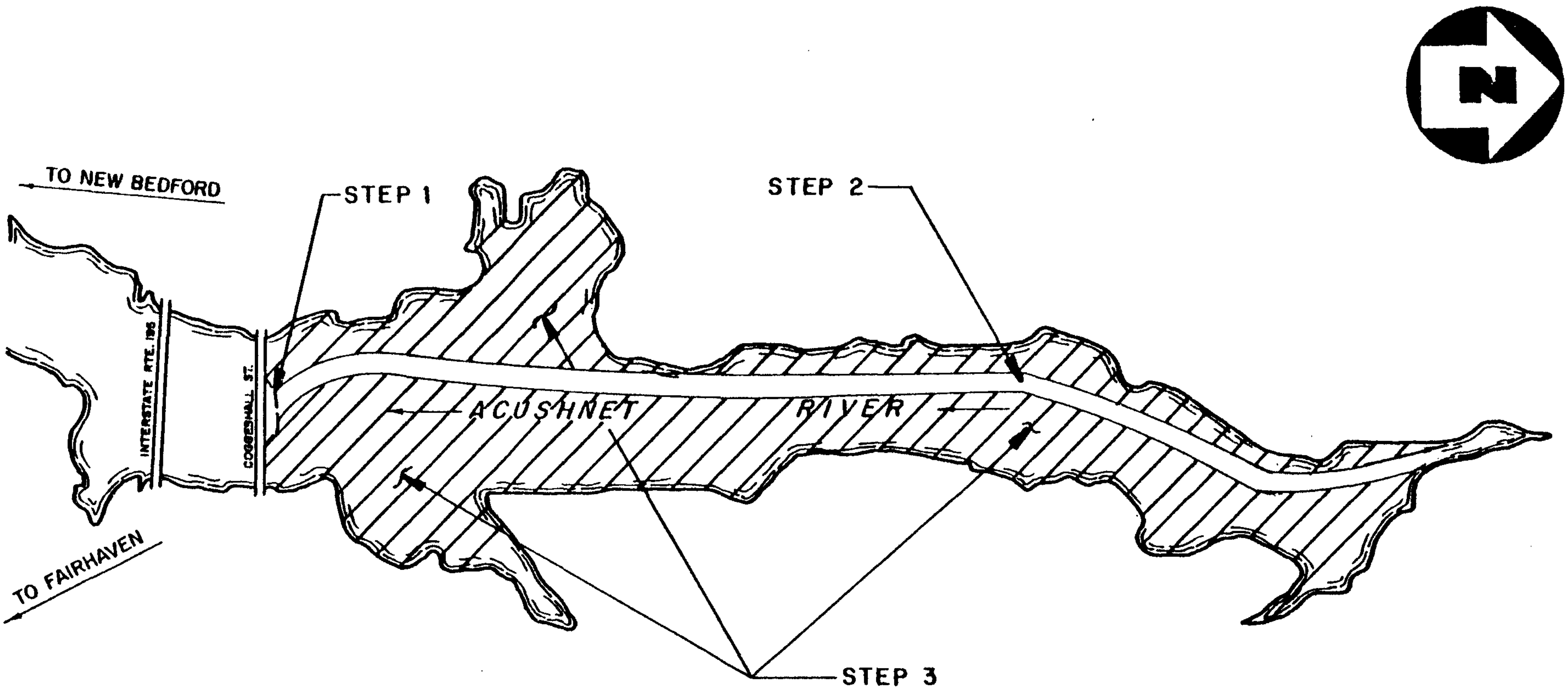
The following subsections describe engineering, construction, and implementation features of the remaining remedial action alternatives. The no-action alternative is not addressed in this section. Prior to construction and implementation of any remedial action, a detailed engineering design will be completed. Review and approval by appropriate regulatory agencies will be necessary throughout all phases of the project.

7.2 Hydraulic Control with Sediment Capping

This alternative requires that the freshwater flows of the Acushnet River be carried by an earthen and rockfill channel constructed along the western shoreline of the upper harbor. The river will be channelized using a pair of parallel embankments with a riprapped bottom so that the river flow will be isolated from existing contaminated sediments on the harbor bottom. The embankments will be constructed to a height which will prevent overtopping during flood conditions, except near the harbor opening beneath the Coggeshall Street Bridge, where the embankment height will be lower to allow tidal fluctuations from the lower harbor to pass into the upper harbor. The harbor bottom will be covered with clean fill in order to isolate the contaminated sediments from the water column. Sediment dispersal control will be implemented prior to construction. A plan view of the proposed alternative is presented as Figure 7-1.

Step 1: Install Sediment Dispersal Control

Sheet piling will be driven to form a barrier across the opening under the Coggeshall Street Bridge. In order to develop lateral support, the piling will be driven through the soft harbor sediments and into the underlying sand and gravel layers. The piling will be placed to form a pair of parallel walls, which will be cross-connected and braced by additional sheet pile sections attached to the walls



STEP 1 – INSTALL SEDIMENT DISPERSAL CONTROL.

STEP 2 – CONSTRUCT DOUBLE EMBANKMENT CHANNEL (APPROXIMATE ALIGNMENT INDICATED).

STEP 3 – CAP SEDIMENTS.

0 1000 2000

SCALE IN FEET

FIGURE 7-1

PLAN VIEW OF HARBOR ILLUSTRATING HYDRAULIC CONTROL ALTERNATIVE NEW BEDFORD SITE, NEW BEDFORD, MA

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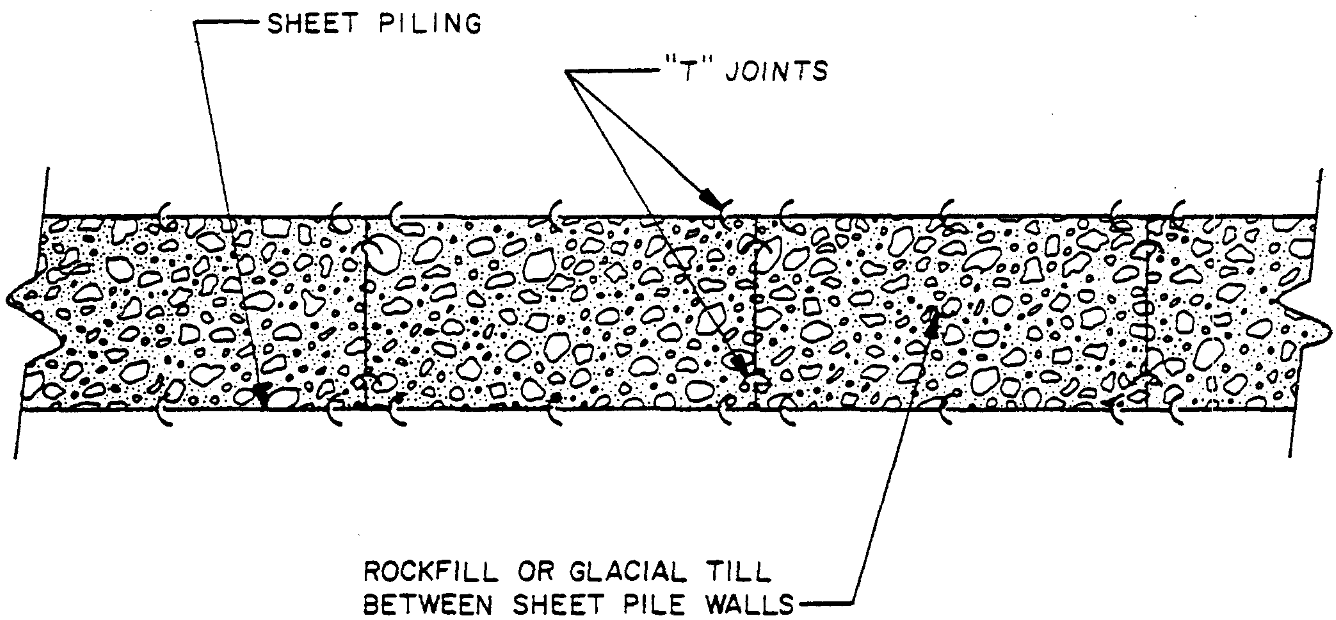
with "T" joints. Rockfill or glacial till will then be placed into the space between the walls, as shown on Figure 7-2, to give the combined structure additional resistance to lateral forces created by tidal fluctuations. The top of this structure should be approximately at the mean low tide elevation so that tidal-waters can freely pass over the top of the piling. The depth to which the sheet piling should be driven will depend on the characteristics and depths of the subsurface materials, and further investigation of these parameters will be required for final design.

A double silt curtain is to be employed in conjunction with the sheet piling. The curtains, which will be suspended from buoys on the water surface, will be located upstream of the sheet piling at a distance that is beyond the effects of water velocity increases over the piling walls. Weights will be attached to the bottom of the skirt in order to maintain proper positioning of the curtain. As an optimum condition, the skirt should extend to within 1 to 2 feet of the harbor bottom, but should not exceed 10 feet in depth. However, in deeper water the curtain will be farther from the harbor bottom, but should still be effective in providing a downward movement of the suspended solids which will then be trapped behind the sheet pile wall.

A section which depicts the proposed control mechanisms is presented as Figure 7-3. The sediment dispersal control mechanisms must be removed in order to complete construction of the earthen channel.

Step 2: Construct Double Embankment Channel

In order to provide a proper base for the channel embankments, a sand blanket must be placed on the existing sediments. Tibbetts Engineering Corporation has previously engineered a major fill project in the lower harbor utilizing such a blanket. A 4-foot thickness of sand was found to be sufficient for surcharges of comparable magnitude to those expected for this alternative, although this thickness may vary greatly depending on the thickness and properties of the silt layer in the upper harbor. It is recommended that the granular blanket be placed



PLAN VIEW OF SHEET PILE WALL
SEDIMENT DISPERSAL CONTROL
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA

NOT TO SCALE

FIGURE 7-2

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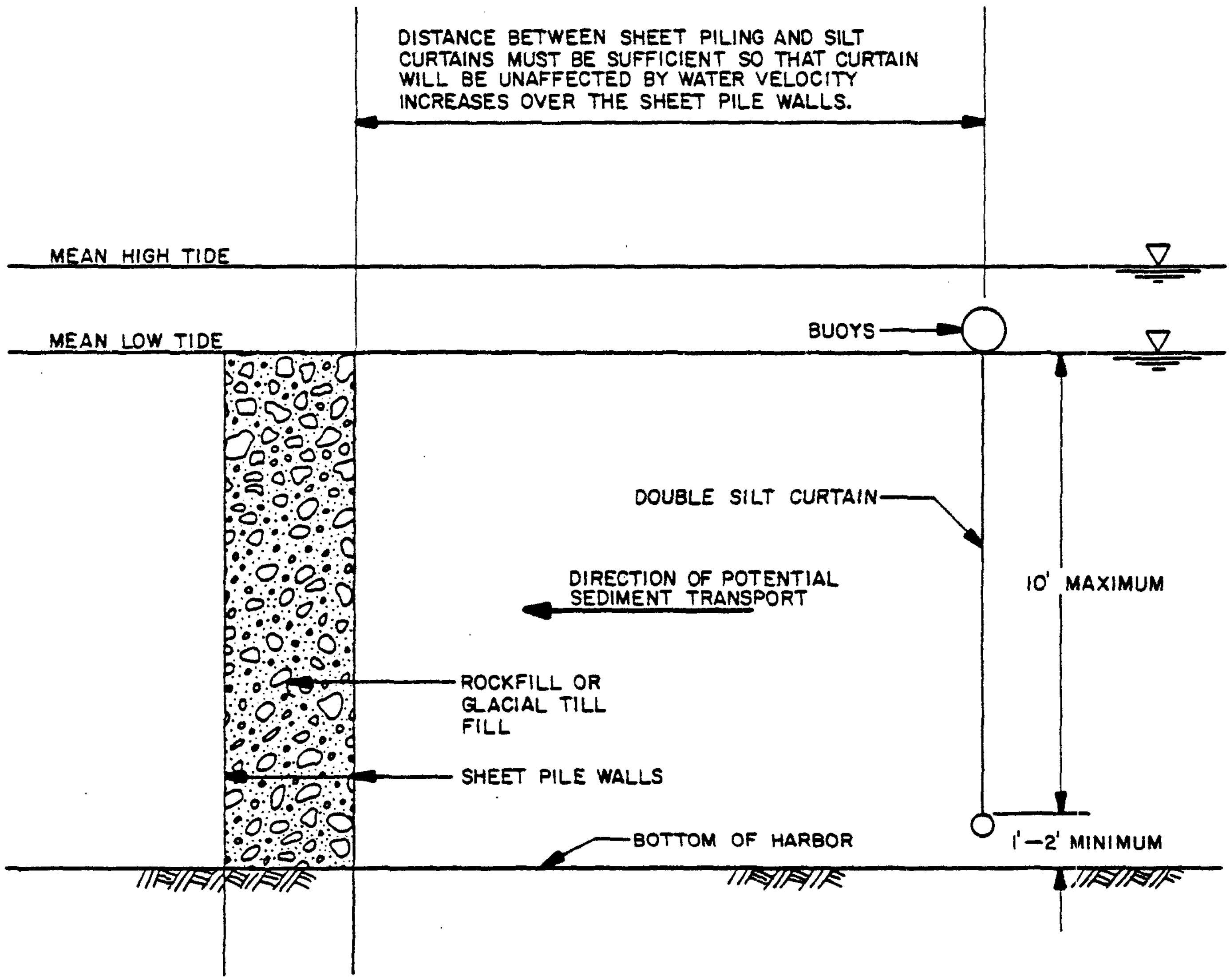

TYPICAL CROSS SECTION
SEDIMENT DISPERSAL CONTROL
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA

NOT TO SCALE

FIGURE 7-3

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so as to extend beneath both embankments and the proposed channel bottom in-between, as well as at least a 15-foot distance beyond the limits of the embankments.

Glacial till will next be placed in order to construct the core of the two embankments. Till will be dumped and spread onto the blanket until the material is even with the existing water level. The till will then be placed in 6-inch lifts and compacted using a smooth-wheeled roller. Other methods of compaction may also be suitable depending on the properties of the buried silts. The embankments will be constructed with sideslopes of 2 horizontal units to 1 vertical unit (2H:1V) and to a final grade of at least +8 feet mean sea level (msl). The elevation of the embankment near the Coggeshall Street Bridge shall be lower than adjacent embankment elevations. This will allow some tidal flows to pass from the lower harbor into the upper estuary in order to maintain a water exchange with open-water areas outside the channel, thus preventing stagnant water conditions from developing. The top of the embankment in this area has been set at +1 foot (msl) so that an exchange will occur during approximately half of the tidal cycle (Figure 7-4). Upon completion of the placement of the glacial till, a filter fabric will be placed over the till in order to minimize transport of fine (and possibly contaminated) sediments through the embankment cores. In order to protect the core from the erosional effects of both wave action in the harbor and open channel flow between the embankments, the faces of the embankments will be covered with rip-rap. The rip-rap layer will be approximately 3 feet thick, and will be sized to withstand the expected erosional forces. Topsoil will be placed on the top of each embankment. The topsoil will provide a suitable material for the establishment of vegetation and a smooth surface for the facilitation of maintenance and access. A typical channel cross section is presented as Figure 7-5.

Since the properties of the harbor sediments are not conclusively known, as mentioned in Section 2.6, it is recommended that engineering studies be conducted in order to assess the stability of the channel embankments with respect to slope

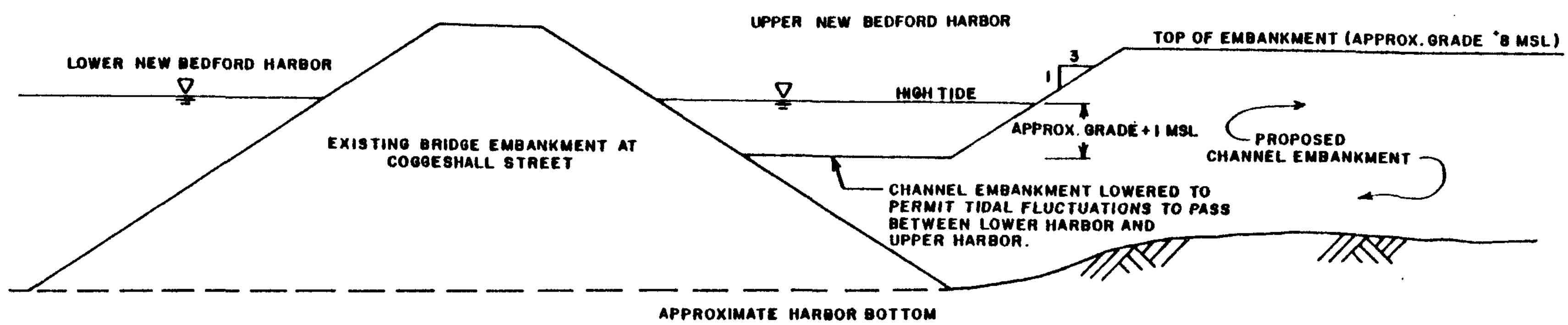

FIGURE 7-4

CROSS SECTION
CHANNEL EMBANKMENT AT THE COGGESHALL STREET BRIDGE
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA
NOT TO SCALE

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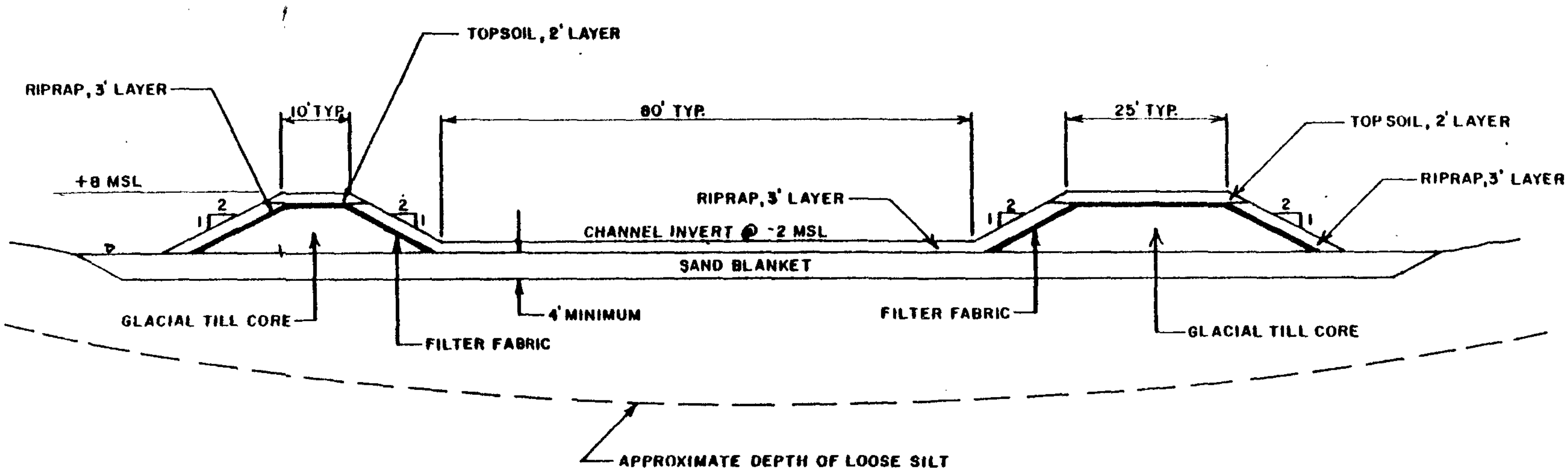

TYPICAL CROSS-SECTION
DOUBLE EMBANKMENT CHANNEL
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA
NOT TO SCALE

FIGURE 7-5

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stability and bearing capacity failures. Engineering analyses should also be conducted to determine the potential for excessive settlement of the embankments. If it is determined that this potential exists, additional embankment height will be required to assure a final grade of +8 feet (msl).

Step 3: Cover Existing Sediments

The areas of contaminated harbor bottom located on both sides of the channel will be covered with clean sediment fill in order to isolate the contaminated sediments from direct human exposure, bottom feeding organisms, and the harbor waters. Previous studies (O'Connor, 1980, NUS. 1983) have indicated that a 3- to 4-foot thick layer of clean material may be appropriate for proper isolation, although the thickness will depend on the physical properties of both the contaminated sediments and the cover material. Clean sediments will be obtained from Buzzard's Bay by using conventional dredging practices. The material will be loaded onto barges, and transported to the downstream side of the I-195 Bridge, at which point further transportation by barge/tug becomes infeasible due to the lack of clearance under the bridge. Pumps will be utilized to remove the sediments from the barge, and the material will be transported by a hydraulic pipeline to the desired discharge point in the upper harbor. Care must be taken in the placement of the cover material so that contaminated sediments are not greatly disturbed and resuspended from the harbor bottom.

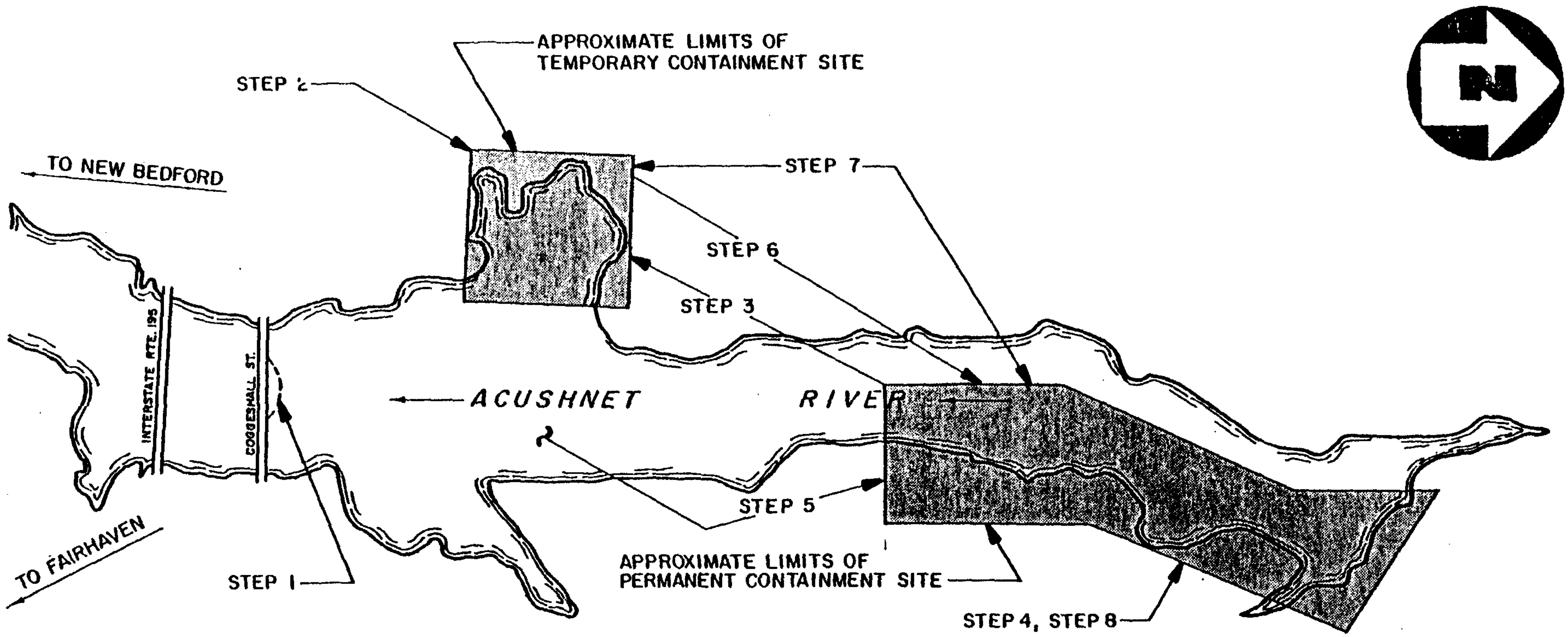
7.3 Sediment Dredging with In-Harbor Disposal

This alternative requires the contaminated sediments to be dredged from the upper harbor and disposed in an in-harbor containment site. Before dredging begins, sediment dispersal control structures will be installed at the harbor opening beneath the Coggeshall Street Bridge. The southernmost cove on the western shore of the upper harbor will be used as a temporary containment site by constructing an earthen retaining embankment. Sediments from the proposed location of the in-harbor containment site embankment will be dredged and pumped to the temporary containment site. Next the in-harbor containment site embankment will be constructed of earthen materials and lined on the disposal side, which will isolate the contaminant area from the Acushnet River and harbor waters. Dredging of the remaining areas outside of the embankments in the upper harbor will then proceed with the spoils being pumped to the permanent containment site; previously dredged sediments contained in the temporary site will be concurrently pumped to the permanent site. All resultant supernatant water in both containment sites will be removed for subsequent treatment in order to eliminate the potential for recontamination of the estuary. Finally, the permanent containment site will be capped to further isolate the contaminants. A plan view indicating the sequential steps of this alternative is presented as Figure 7-6.

If required, a similar alternative could be implemented that will utilize a fully lined site instead of a partially lined site. The additional liner will completely underlie the site and will serve to isolate the contaminants from groundwater systems beneath and adjacent to the harbor. Such an alternative will require that contaminated sediments beneath the proposed in-harbor containment site be removed prior to liner placement if the full intent of the liner is to be realized. Those sediments beneath and outside of the containment embankment must also be removed. The material dredged from underneath the embankments and inside the containment area will be stored in the temporary containment site until completion of the liner placement. All contaminated sediments will then be disposed in the containment site, as above.

Step 1: Install Sediment Dispersal Control

The sediment dispersal control structures will be designed and constructed in the same manner as discussed under the hydraulic control alternative. Removal of the sheet piling and curtains will take place following the completion of all dredging activities.



STEP 1 - INSTALL SEDIMENT DISPERSAL CONTROL.
STEP 2 - CONSTRUCT TEMPORARY CONTAINMENT SITE.
STEP 3 - DREDGE BENEATH EMBANKMENT. HOLD IN TEMPORARY CONTAINMENT SITE.
STEP 4 - CONSTRUCT PERMANENT CONTAINMENT SITE.
STEP 5 - DREDGE-DISPOSE IN PERMANENT CONTAINMENT SITE.
STEP 6 - TRANSPORT SEDIMENTS FROM TEMPORARY CONTAINMENT SITE TO PERMANENT CONTAINMENT SITE.
STEP 7 - TREAT WATER.
STEP 8 - CAP CONTAINMENT SITE.

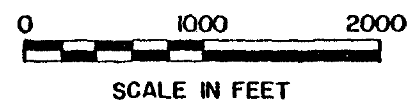


FIGURE 7-6

PLAN VIEW OF HARBOR ILLUSTRATING
IN-HARBOR CONTAINMENT ALTERNATIVE
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA

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Step 2: Construct Temporary Containment Site

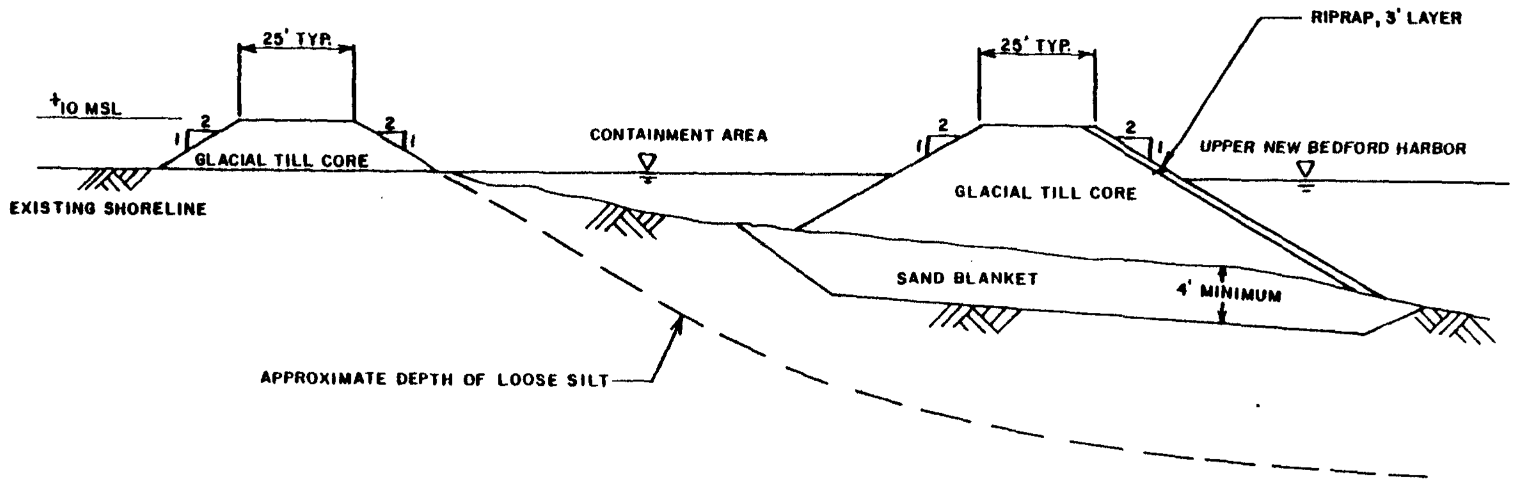
The southernmost cove on the western shore of the upper harbor will be utilized as a temporary containment site. A sand blanket will first be placed on existing sediments to provide adequate support for the glacial till embankment. The 6-inch lifts, with 2H:1V side slopes. Material placed on the existing shoreline can thickness of this blanket will be approximately 4 feet, but may be greater depending on physical properties of the harbor sediments. Glacial till will then be placed either on the sand blanket or existing shoreline to form a containment embankment with final grade at approximately +10 msl. The fill will be placed in be compacted using a vibratory roller. However, vibratory compaction methods may not be suitable for in-harbor use due to the potential for liquifaction of the underlying fine-grained material. Finally, the embankment will be covered with riprap on the side adjacent to the harbor. A typical cross-section of the temporary containment site is presented as Figure 7-7.

Step 3: Dredge and Dispose in Temporary Containment Site

Since a permanent in-harbor disposal site is to be constructed, initial dredging activities will remove sediments from the approximate location of the proposed containment embankment. A hydraulic pipeline cutterhead dredge will be used for all proposed dredging operations, fitted with a bucketwheel cutterhead that has recirculating capacity for the dredged water. This type of dredge can be used at dredging rates of 70 to 250 yd^3/hr (in-situ sediments). The production rate is variable, depending on the sediment particle size and the equipment size. Typical dredge cuts will be approximately 3 feet in depth. The hydraulic pipeline will convey the slurry to the temporary containment area.

Step 4: Construct Permanent Containment Site

Upon completion of dredging of the proposed containment embankment area, a sand blanket will first be placed to develop subgrade support for the embankment.



TYPICAL CROSS-SECTION
TEMPORARY CONTAINMENT SITE
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA
NOT TO SCALE

FIGURE 7-7

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Next, the glacial till core will be placed and compacted as discussed previously, to a final elevation in excess of +8 feet msl. Outward sideslopes will be 2H:1V, but the inward sideslopes will be 2.5H:1V, which is more suitable for the later placement of a membrane liner.

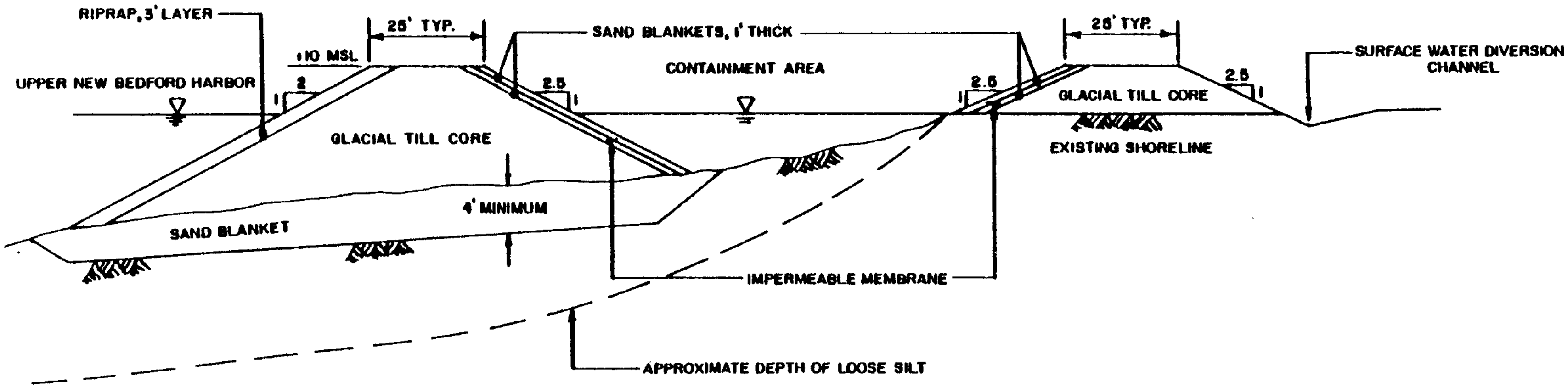
An impermeable membrane will be installed on the inward face of the containment enbankment in order to stop contaminant migration from the containment site through the embankment. To protect the membrane, a 1-foot thick layer of sand will be placed both underneath and on top of the liner. The portion of the embankment which faces the open harbor will be covered with a 3-foot thick layer of riprap for erosion protection. Figure 7-8 presents a typical cross-section through a partially lined, in-harbor containment site.

Step 5: Dredge and Dispose in Permanent Containment Site

All remaining areas outside of the containment site will be dredged to an approximate depth of 3 feet below the present sediment surface. Dredge spoils will be pumped via a pipeline directly into the permanent containment site.

Step 6: Transport Sediment from Temporary Containment Site to Permanent Containment Site

Sediments contained in the temporary containment site will be removed by a dredge and transported by a pipeline of between 6 and 12 inches in diameter. Additional booster pumps should not be required for the pumping distances expected. The appropriate pipeline size and pumping rate may vary depending on 1) the dredging rate and storage capacity of the containment site, and 2) the dredged sediment properties (void ratio and grain size). Hydraulic transport of sediments from the temporary containment site can be accomplished concurrently with the dredging of the rest of the upper harbor.



7-15

TYPICAL CROSS SECTION
PARTIALLY LINED IN-HARBOR CONTAINMENT SITE
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA
NOT TO SCALE

FIGURE 7-8

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Step 7: Treat Water

Water to be treated will be of two origins:

- Surface water within the containment sites which was originally a portion of the harbor water body, and was subsequently trapped upon construction of the containment site.

- Supernatant water from the dewatering of the dredge spoils.

Since both will contain potentially contaminated suspended solids, all of the water will be decanted from the surface of the containment site and transferred by pumps and pipeline to a treatment plant. The major components of the treatment plant will include a flow equalization tank, chemical addition tank, clarifier, and filters filled with Klensorb and activated carbon (or variation thereof), as shown in Figure 7-9. Baffles will be added to the flow equilization tank for grit removal. Design flow rates will depend on both the dredging rate and the storage capacity of the containment sites. The overall plant design is dependent on the contamination types and levels found in the water, and both bench and pilot scale studies will be required for final design. Water quality monitoring of the effluent from the treatment plant will be necessary in order to satisfy discharge permitting requirements.

Step 8: Cap Containment Site

After completion of the dewatering of sediments within the permanent containment site, the landfill will be capped with an impermeable membrane. A 1-foot thick sand layer will be placed on both the top and underside of the membrane. Two feet of topsoil will then be placed as the final cover, and the entire site revegetated. The top of the landfill will be graded to slope away from the harbor at a minimum 2 percent slope in order to limit surface runoff on the harbor side of the site and subsequent flushing of fine grained material from within

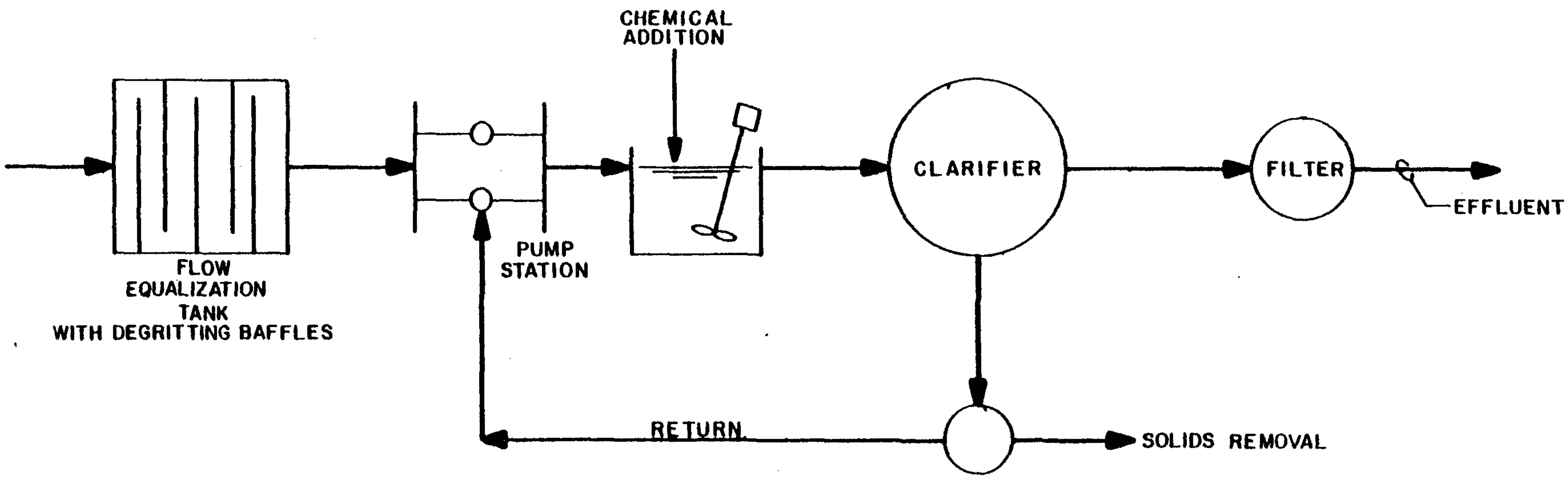

FIGURE 7-9

WATER TREATMENT PLANT SCHEMATIC
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA

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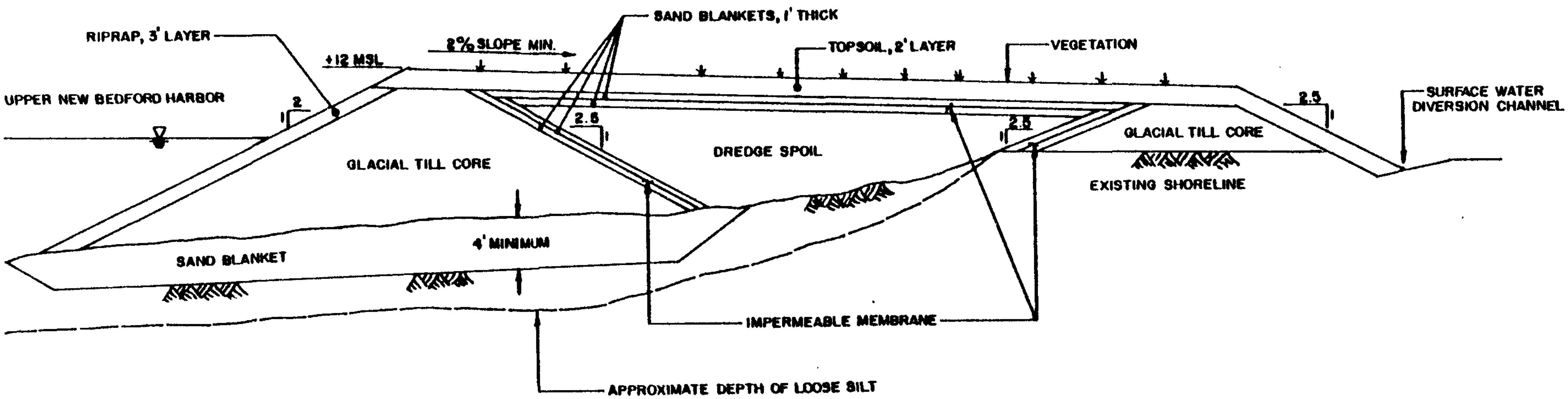

7-18

TYPICAL CROSS-SECTION

PARTIALLY LINED IN-HARBOR CONTAINMENT SITE WITH CAP

NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA

NOT TO SCALE

FIGURE 7-10

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the rip-rap layer. Surface water control will be implemented as necessary. A cross section of an in-harbor containment site cap is presented as Figure 7-10.

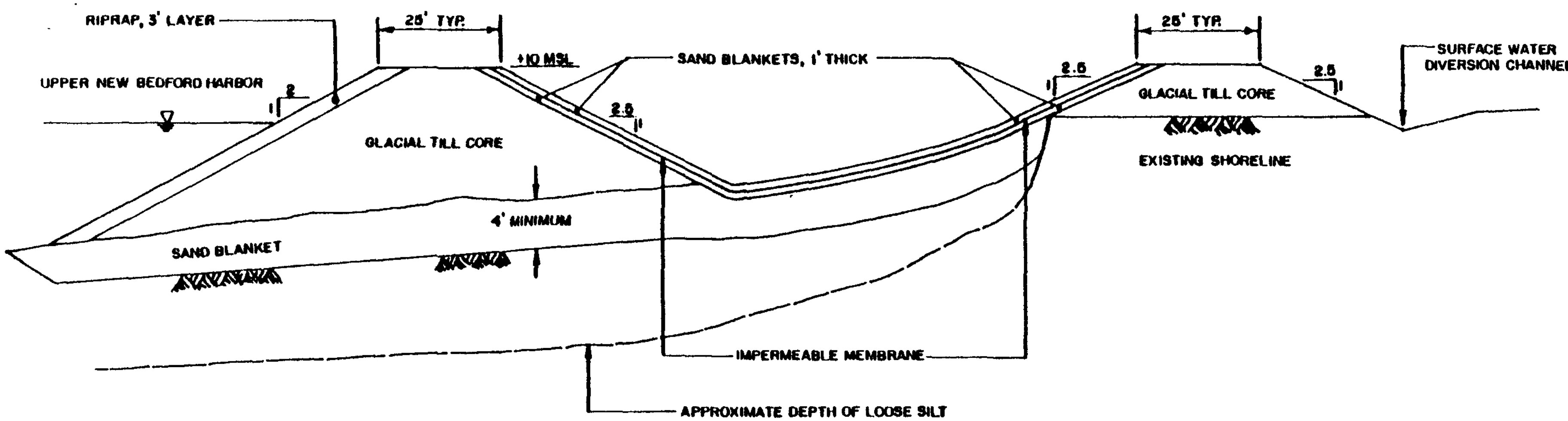
7.3.1 Construction of a Lined In-Harbor Containment Site

If the decision is made to develop a lined in-harbor containment site, sediments will be dredged from the containment site area by the previously described technique/equipment and placed into the temporary containment site. A 4-foot thick layer of sand will be placed over the bottom of the entire containment site area. The permanent containment site embankment will next be constructed, and the containment site will be lined with an impermeable membrane protected on both sides with a 1-foot thick layer of sand. Dewatering of the containment site prior to liner placement will probably be required. A system of wellpoints should be suitable, although it is possible that a sheet pile cut-off wall may be more cost-effective depending on localized groundwater dynamics. Either system will be very costly. Figure 7-11 presents a typical cross section through a fully lined in-harbor containment site.

Cellular construction of the permanent containment site may be necessary if the dredge spoil volume exceeds the storage capacity available in the temporary containment site, and also to aid in the dewatering of the containment site area.

7.4 Sediment Dredging with Upland Disposal

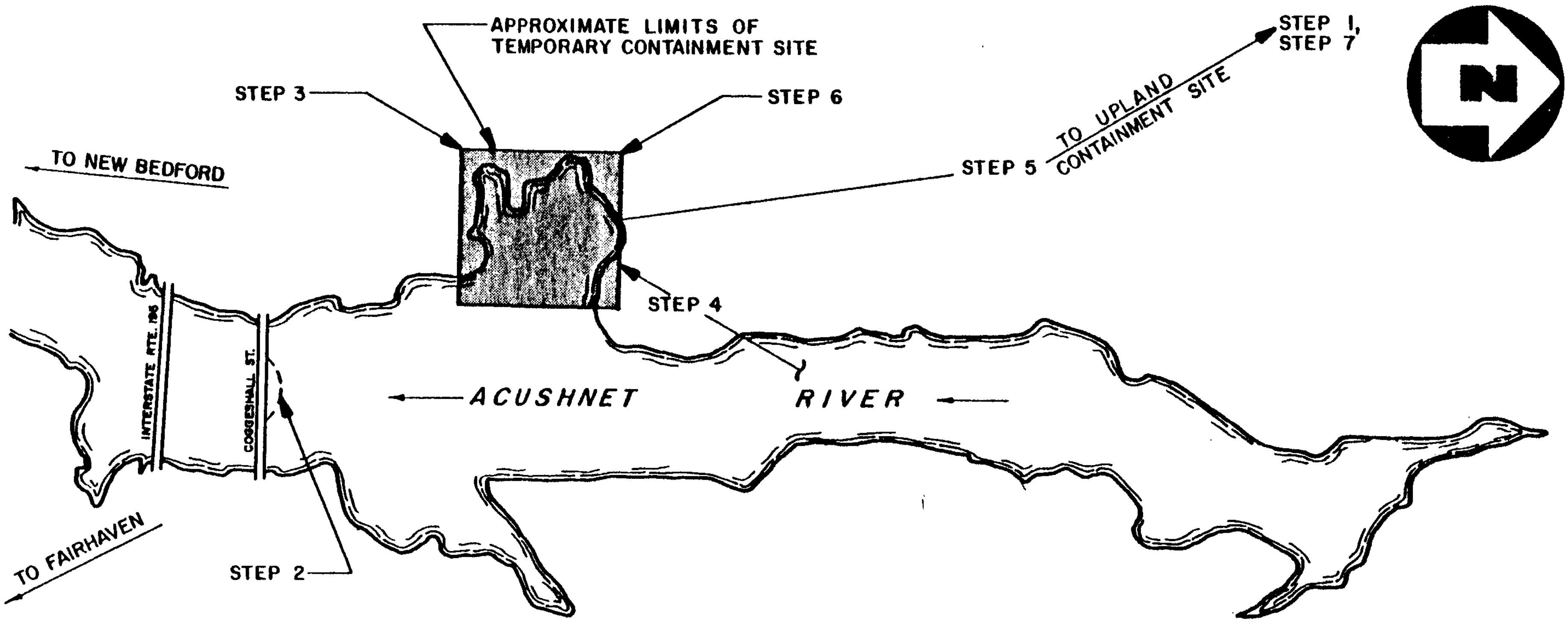
This alternative requires that the contaminated sediments be dredged and disposed in an upland containment site. Initially, a disposal facility for contaminated dredge spoils will be developed at a suitable upland location. As with the other dredging alternatives, sediment dispersal control structures will be installed at the mouth of the upper harbor before in-harbor operations begin. A temporary containment site will be constructed in the cove on the western shore of the upper harbor, near the Coggeshall Street Bridge. Harbor sediments will be dredged and conveyed to the temporary site. Upon dewatering, the contaminated sediments will be removed



TYPICAL CROSS SECTION
LINED IN-HARBOR CONTAINMENT SITE
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA
NOT TO SCALE

FIGURE 7-11

NUS CORPORATION
A Halliburton Company



STEP 1 – CONSTRUCT UPLAND CONTAINMENT SITE.
STEP 2 – INSTALL SEDIMENT DISPERSAL CONTROL.
STEP 3 – CONSTRUCT TEMPORARY CONTAINMENT SITE.
STEP 4 – DREDGE-HOLD IN TEMPORARY CONTAINMENT SITE.
STEP 5 – TRANSPORT SEDIMENTS FROM TEMPORARY CONTAINMENT SITE TO PERMANENT CONTAINMENT SITE.
STEP 6 – TREAT WATER.
STEP 7 – CAP CONTAINMENT SITE.

0 1000 2000
SCALE IN FEET

FIGURE 7-12

PLAN VIEW OF HARBOR ILLUSTRATING UPLAND CONTAINMENT ALTERNATIVE NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company

from the lagoon and transferred to trucks for transportation to the upland disposal site. All decanted water will undergo treatment to remove contaminants. When all sediments have been disposed into the containment facility, the landfill will be capped to reduce/eliminate surface water infiltration. A plan view depicting the sequential steps of this alternative is presented as Figure 7-12.

Step 1: Construct Upland Containment Site

The location of an upland containment site for disposal of contaminated harbor sediments will be determined after completion of a detailed siting study. Possible locations are under consideration within a 10-mile radius of the New Bedford Harbor.

The selected site will first be cleared and grubbed, and then the slopes graded to permit adequate drainage of the leachate collection system. Embankments will next be constructed of glacial till from a local source to form the retaining walls of the containment site. Fill material will be placed in 6-inch lifts and compacted with a vibratory roller; embankment sideslopes will be 2.5H:1V. The areal extent of the containment site and height of the embankments will depend on design considerations such as the total required containment volume, available containment site area, etc. A membrane liner will be placed on the bottom and sideslopes of the containment area, protected on both sides by a 1-foot thick blanket of sand. The leachate collection system, which will be constructed of 6- inch PVC pipe, will be located in the middle of the upper sand layer. A typical cross-section of an upland containment site is presented as Figure 7-13.

Step 2: Install Sediment Dispersal Control

Sediment dispersal control will be installed prior to dredging. Construction will be the same as that described for the other alternatives. The control mechanisms will be removed after completion of dredging activities.

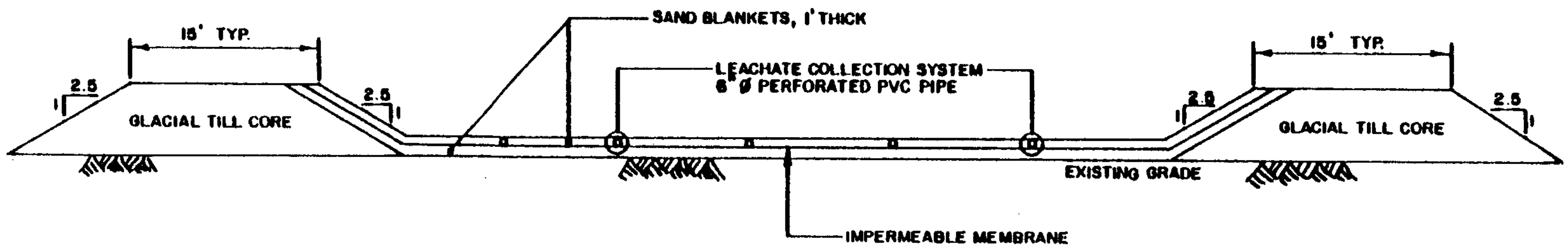


FIGURE 7-13

TYPICAL CROSS SECTION
UPLAND CONTAINMENT SITE
NEW BEDFORD HARBOR SITE, NEW BEDFORD, MA
NOT TO SCALE

NUS CORPORATION
A Halliburton Company

Step 3: Construct Temporary Containment Site

All dredged sediments will require primary solids dewatering before hauling to the upland containment site. Consequently, a temporary containment site will be constructed in the cove on the western shoreline of the upper harbor by the method previously described. The site will be suitable for the temporary containment of sediments prior to hauling and for the decanting and treatment of contaminated water.

Step 4: Dredge-Disposal in Temporary Containment Site

The entire upper harbor will be dredged using the previously described equipment and the dredge spoils will be pumped by pipeline to the temporary containment site.

Step 5: Transport Sediments from Temporary Containment Site to Upland Containment Site

After dewatering, the remaining solids will be removed from the temporary containment site and hauled to final disposition at the upland site. Sediments will be removed from the temporary containment site using a clamshell bucket and deposited into lined dump trucks. Tank trucks should not be required if the sediments are dewatered to a suitable percent solids.

Step 6: Treat Water

Displaced surface water as well as free water obtained from the dredge spoils during dewatering will require treatment. The water will be decanted from the surface of the temporary containment site and pumped to the treatment plant, which will be designed as discussed for the previous dredging alternative.

Step 7: Cap Containment Site

Once all of the sediments are disposed into the permanent containment site, the landfill will be capped in order to reduce/eliminate surface water infiltration and corresponding leachate generation. A minimum 1-foot thick layer of sand will first be laid on top of the spoil material, followed by placement of an impermeable membrane on top. One additional foot of sand will then be placed on top of the membrane. Finally, the entire containment facility will be covered with two feet of topsoil and revegetated. The cap will be graded at a slope of at least 2 percent so as to drain away from the center of the landfill. Surface water control will be utilized to direct surface water flows around the containment site.

Step 8: Monitoring

Groundwater monitoring wells would be required upgradient and downgradient of the containment site. Samples of the groundwater would be taken on a regular basis to satisfy permit requirements. Periodic visual inspections of the landfill for seeps, cracks, or erosion would also be appropriate.

8.0 EVALUATION OF REMEDIAL ACTION ALTERNATIVES

The cost-effectiveness criteria for the evaluation of remedial action alternatives, as described in Section 6.0, focus primarily on the relative benefits of each alternative to mitigate health risks and environmental impacts. In the case under study, however, the actions to remediate the hot-spot areas also involve negative health, environmental, and community impacts that are potentially key decision criteria in the acceptability and implementability of a given action. The evaluation of alternatives in this section will address both the beneficial and adverse impacts and will be organized by type of impact (or effectiveness measure) rather than by individual alternative. Several of the cost-effectiveness measures identified in Section 6.0 will be incorporated into more comprehensive discussions of environmental, public health, and public welfare/community impacts (Sections 8.1-8.3). Others will be treated separately in Section 8.4, as will project costs in Section 8.5.

8.1 Environmental Impacts

8.1.1 No-Action Alternative

The current levels of PCB and heavy metal contamination in the sediment, water, biota, and air environments of the Acushnet River Estuary were discussed in Section 3.2. The no-action alternative will sustain these and other contaminant levels.

Impacts on Aquatic Biota

Fish accumulate PCBs by both direct water uptake and the ingestion of lower aquatic organisms in the food chain. Because PCBs are persistent in the body tissues of both the food source and the fish, bioaccumulation occurs in fish to several orders of magnitude greater than ambient water concentrations. Larger fishes, bottom feeders, and carnivorous predators exhibit the highest levels of bioaccumulation. In addition, biomagnification takes place as evidenced by the higher and higher concentrations of PCBs found as the organizational level of the ecological niche is elevated.

As stated in Section 3.2, many species of fish and shellfish already exceed the FDA limit of 2 ppm PCBs in the edible portion, while several other species have average concentrations close to the FDA limit. Whether concentrations in these species will increase, remain at current levels, or decrease under the no-action alternative depends on the relative rates of PCB uptake and depuration. It is expected that species within the hot-spot areas will continue to bioaccumulate PCBs and that concentration levels may remain at the currently elevated values and could even progressively increase. This may not be the case in less-contaminated areas or areas where the deposition of clean sediments has occurred. Even in the latter case, however, the continued presence of PCBs will significantly delay the recovery process, and it is unlikely that some species (e.g., eels, lobsters) will achieve the FDA action limit within an acceptable length of time.

Invertebrate species tolerant of PCBs have become established in the river. The continued presence of contaminants will prevent the introduction of species less tolerant of contamination, and thus, species diversity.

Recent data have indicated that a few centimeters of clean sediments now cover the contaminated sediments in some areas of the estuary (GCA, 1984). One could conjecture that a continuation of the sedimentation process would eventually render PCBs unavailable to the food chain. However, the uncontrolled hydrodynamic character of the estuary, the silty nature of the upper sediment, and the shallow depths over most of the hot spots could lead to a turnover of the sediments under periodic flood or high wind conditions. Since sedimentation is only occurring at an estimated rate of several centimeters per year, the environmental and related risks would be high if one opts for a no-action alternative on the basis of recent deposition of clean sediment.

Impacts on Waterfowl and Animals

The no action alternative will not alleviate the possible increase of PCBs, metals, and possibly other contaminants in birds, waterfowl, and other terrestrial animals that feed in the Acushnet River Estuary, along its tidal flats, and within the contiguous wetlands. The routine consumption of contaminated fish, invertebrate, and plants by permanent resident animals will result in greater bioaccumulation than in migratory species. Little is known about the ability of animals to resist stresses from PCB contamination, and the contaminant-induced changes on behavior and reproduction.

Aquatic Vegetation

The aquatic vegetation along the shorelines and within wetland areas is currently impacted by contaminants in the water column and sediments. Because hydrodynamic patterns of the upper estuary would not favor a quick flushing of these protected areas, current levels of contaminants are expected to remain for a long period of time. Continued sedimentation could result in a clean cover over the contaminants, but the root zone of the emergent vegetation would still penetrate heavily-contaminated zones.

Air Resources

Recent air quality data from monitors located upwind and downwind of the hot-spot area indicate that the area is a low-level source of PCBs to the ambient air (GCA, 1983). Under the no-action alternative, conditions corresponding to maximum volatilization potential (e.g., wet and exposed mudflats) will persist, and the low-level release of PCBs by volatilization or attachment and movement with particulates will continue.

8.1.2 Hydraulic Control with Sediment Capping

This alternative involves two principal activities in relation to environmental impacts. These are the construction of the channel itself and the placement of a sediment cap over the remaining open-water areas. Each activity is addressed below.

Impacts of Channel Construction

Any time a natural watercourse is channelized, significant environmental changes occur, not all of which are permanent or adverse. Channelizing the Acushnet River would most severely disrupt aquatic life. Eventually, a substrata would be reestablished from which a complete ecosystem would develop. Fish may be among the first to reenter the new channel, but no resident populations would be established until aquatic invertebrates and plants returned. The new community may be composed of different species than those now in existence because the creation of an artificial channel with a rock-facing would not provide the same habitat as the existing sandy and silty river bottom. In addition, streamflow velocity would be greater and more persistent for the channelized flow. The new channel would be of uniform dimension, eliminating the shallow water and slow velocity areas that provide breeding and feeding areas for aquatic species.

Channelizing the Acushnet River would also alter flood conditions in the estuary. Marshy areas along the river banks serve as floodwater retention areas, and replacing the marshes with a rock-faced channel would result in increased flood velocities. Increased flood velocities would, in turn, have a more severe impact on the aquatic species that have established themselves in the new channel. Note that flooding itself would be reduced since the channel has been designed to convey the 100-year flood without overtopping. Downstream impacts of channelized flood flows will be minimal. All flow will still enter the downstream harbor through the Coggeshall Street Bridge opening, and flood velocities in the flat channel will not be increased significantly enough to affect the open harbor below the bridge. Note that circulation patterns in the harbor are controlled more by the dynamics of

Buzzards Bay and the outer harbor rather than by the freshwater flows from the Acushnet River.

Impacts of Underwater Sediment Cap

During construction, the existing substrata and benthic organisms will be covered and will likely be destroyed. However, the existing population is sparse and the impacts will consequently not be severe. Over time aquatic communities should re-establish themselves. Some resuspension of contaminated sediments is expected as the cover material is placed, but this should quickly settle in the immediate vicinity of the operation. The restriction of flow to the channel will prohibit any movement of contaminated materials to downstream areas.

Installing a cap over the contaminated sediments would decrease the acreage of aquatic habitat available, but would eventually permit the establishment of aquatic vegetation in a relatively clean environment. Mobile species would leave the area as construction occurs, but could eventually return upon completion.

Wetland areas, particularly those along the eastern shoreline, would be impacted in two ways. First, the present contamination in these areas would require a capping operation. The cap would cover much of the vegetation and would in fact eliminate much of the current wetland area due to the existing shallow waters in these areas and the necessary depth of cover. New wetland areas would be formed further out into the estuary. Second, because the salinity of the estuary will eventually decrease as the tidal prism is reduced by the channel, the type of vegetation could be modified in those areas that retain a wetland environment.

The implementation of the channel and sediment cap will result in the loss of several hundred acre-feet of available flood storage behind the hurricane barrier. However, this represents a very small percentage of the total available storage, and in the event that the gates of the hurricane barrier are closed, the incremental increase in flood levels caused by the channel and cap will be insignificant (i.e., on the order of an inch).

8.1.3 Sediment Dredging with In-Harbor Disposal (Partially Lined Site)

This remedial action alternative involves dredging, temporary storage of dredged materials, embankment construction, disposal, dewatering, and water treatment operations. Each has specific environmental impacts, as are addressed below.

Impacts of Dredging

The use of sediment dispersal controls at the Coggeshall Street Bridge and in the immediate vicinity of the dredging operation will minimize adverse impacts on aquatic life downstream of the study area. PCBs will generally remain bound to particulate matter that will be effectively contained by the sheet piling and silt curtains. The increased water column concentrations as a result of dispersal and resolubilization will not be significant in relation to overall effects on the aquatic biota. A primary concern is the dispersal of heavily-contaminated oily films from the hot-spot areas. The silt curtains will provide a partial barrier to the downstream migration of these films, particularly if the silt curtain is modified to incorporate some type of absorbent material. The site operations plan must include a quick removal of any collected films to minimize subsequent dispersal and photolysis. The metals are expected to remain as insoluble metal sulfides since the time of particulate transport prior to resettling will not be sufficient to oxidize the sulfides.

Within the actual dredging area, impacts will be more severe, but will not be a permanent disruption. Although sediment dredging will remove the existing substrata, bottom-feeding organisms will not be severely impacted since the populations are currently sparse as a result of the high levels of contamination. The incorporation of a sediment cap in areas beyond the channel and disposal area would provide a clean substrate upon which aquatic communities could quickly reestablish themselves.

Fish and some aquatic invertebrates, because they are mobile, would leave the area being disturbed by dredging. Upon completion of the project, these populations could eventually return, although it is possible that new communities would be established if the salinity drops in the areas partially isolated from tidal flows.

Dredging would also affect terrestrial biota. Populations of fish-eating biota and mammals that currently reside and feed in this section of the river would leave as noise and human activity increase. If none of these species breed in the area, no long-term displacement of individuals would be expected. These terrestrial species would return to feed on the new healthy fish population that becomes established in the estuary.

Some species of birds or other animals could come into contact with the contaminated sediments and water in the harbor and dewatering lagoon, particularly during non-working hours (gulls) and autumn migration periods (waterfowl and shore-birds).

Two critical and beneficial impacts of dredging are changes in the harbor water column PCB concentrations and reduced PCB accumulations in fish. The downstream movement of PCB-contaminated sediments would also be eliminated, thereby resulting in benefits to the overall aquatic community in New Bedford Harbor.

Impacts of Temporary Sediment Storage Area (West Shore Cove)

Constructing a retaining embankment and filling the cove on the western shore as a temporary sediment storage area will destroy the existing marsh communities. However, once the stored sediments and the underlying contaminated sediments are removed to the final disposal site, a clean substrate would be left upon which new communities can build. Because the existing community that has been established in the cove has been impacted by the high levels of PCBs and metals, the long-term effects of this activity would be beneficial. This scenario assumes that the embankment is removed upon completion of the project so that the cove is not cut off from the estuary.

If, on the other hand, sediments are left in the cove or if the embankment is maintained for eventual development of the cove area, a natural aquatic habitat would be lost. Any development of this area would remove the only remaining natural shoreline on the New Bedford side of the estuary.

Even if the retaining wall is removed, the loss of the cove environment will take several years to reverse and the recovery process may not be readily noticed. As a result, there may be persistent public pressure to fill and develop the area on the premise that it is already damaged. The ultimate result of any development would be the same as that mentioned above.

Impacts of Embankment Construction

The impacts of constructing a single embankment would be similar to those previously described for the construction of a hydraulic control channel. The post-construction impacts differ, however. In the case of the single embankment, the estuary along the western shore will remain in its natural condition. The aquatic community that reestablishes itself upon completion of dredging and construction will consequently be similar to that of a comparable marine environment. Shallow water and low velocity areas that provide breeding and feeding areas for aquatic species will be preserved under this alternative. The existence of a rock-lined embankment could result in a beneficial environmental impact by eventually providing a varied environment for the establishment of a more diverse ecologic community.

Another difference between this alternative and the construction of a hydraulic control option is that the contaminated sediments beneath the single embankment will be removed prior to embankment construction. This will, for practical purposes, eliminate the possible impacts of "squeezing out" contaminated sediment and groundwater into the surface water system as the sand blanket and embankment surcharge the underlying materials. Pre-dredging is not as critical in the case of the double embankment channel since the channel is isolated from open-water areas on both sides, and the exchange of waters with downstream areas is more positively controlled.

Channelizing the upper estuary will result in increased flow velocities that could have an effect on the resident aquatic species. This effect will be less than in the case of complete channelization, however, since low-lying shoreline areas will still be available for floodwater retention and flow attenuation.

An overall environmental benefit of the embankment option is its primary role to contain and isolate contaminated materials from the estuary and harbor environments.

Impacts of Partially Lined In-Harbor Disposal Area

Backfilling part of the upper harbor as a disposal site for contaminated sediments would result in the loss of a large portion of the salt marshes on the eastern shore of the river. This not only would destroy the existing aquatic and terrestrial communities that are found in the marsh, but it would prevent the re-establishment of marsh communities once the project is completed. In addition, no significant length of undeveloped shoreline will remain in the harbor upon project completion for the development of new salt marshes to compensate for those lost. Approximately 20 acres of the salt marshes will be lost by the construction of this disposal site.

Countering these concerns is the fact that the salt marshes that would be irreversibly damaged by the disposal area are likely currently impacted by PCBs. Any remedial action of the hot-spot areas (other than the no-action alternative) will necessarily include these marshes due to their location within the areas of highest concentrations. Regardless of the selected action (e.g., dredging, capping), the salt marshes will be seriously impacted including permanent loss of at least partial areas.

By not fully lining the disposal area, groundwater will be free to move through the disposal site. Tidally-induced groundwater flows that typically move in and out of shoreline areas may be reduced, however, by the impermeable embankment on the harbor side of the disposal area. It is unlikely that groundwater flows will significantly mobilize the PCBs and metals even if the flows pass through the site. It is intended to maintain a saturated condition within the containment area itself so that anoxic conditions and metal insolubility are consequently maintained. Any contaminants that are mobilized can be expected to become bound in the nearshore or bottom materials so that the ultimate extent of migration will be limited. The impacts of any groundwater contamination will therefore not be significant since the extent of contamination will likely be limited to areas with saline groundwater that are not groundwater usage areas.

The construction of the disposal area will not have long-term adverse impacts on the aquatic community. Mobile species will likely move from the construction area to other areas of the harbor that will eventually be dredged and cleaned. The benthic community will be irreversibly damaged by the disposal area, but again the present state of this community is stressed. On the beneficial side, the area removed from aquatic habitat will be added to a protected terrestrial habitat upon completion of the project.

Impacts of Dewatering

The dewatering of sediments under this alternative will be incorporated into the overall disposal area construction and operation. Three specific environmental concerns associated with the dewatering operation are the potential (though limited) volatization of PCBs as the sediments become exposed upon dewatering, the possible oxidation and mobilization of metals in the upper zones if exposure to the atmosphere is maintained, and the existence of a free water surface that could attract waterfowl and mammals to contaminated areas.

Impacts of Water Treatment

Supernatant from the dewatering operation will be processed through a package water treatment plant. The water would be treated to PCB levels below 1 ppb, and the effluent would be discharged to the harbor. Discharge to a municipal sewer system is possible, but the high flow rate and salinity of the water may impose irreconcilable constraints on this option. The treatment of supernatant water will considerably reduce the potential health risks and environmental impacts of the dewatering/disposal operation.

A small parcel of land will be needed for the water treatment facility and discharge pipe easement. This land will be removed from other uses until the cleanup is complete, at which time the plant will be dismantled. No permanent adverse impacts would result from the construction and operation of the water treatment facility.

8.1.4 Sediment Dredging with In-Harbor Disposal (Lined Site)

The environmental impacts associated with this alternative are largely comparable to those of the partially lined site. A principal exception is the reduced potential for groundwater contamination even if PCB and heavy metal mobilization does occur. An increased environmental risk also occurs due to the need to initially dredge the contaminated sediments underlying the embankment and liner (including the wetland areas), and to dewater the disposal area prior to liner installation. It will also be necessary under this alternative to provide a temporary storage area (and the ancillary dewatering and treatment facilities) for the sediments removed prior to liner installation. This was discussed under the partially lined site alternative. One point of concern in the installation of an impermeable membrane liner is whether gas build-up will occur beneath the liner due to biological or chemical activity in the underlying sediments. It is judged that this potential problem should be minimal since the upper 3 feet of sediment will be dredged prior to liner placement and a 4-foot thick sand blanket will directly underlie the liner.

8.1.5 Sediment Dredging with Upland Disposal

The alternative of sediment dredging with upland disposal involves four principal operations impacting on environmental issues: dredging; dewatering in a temporary storage area using the cove on the western shore; transport to the disposal site; and the construction, operation, and environmental soundness of the upland landfill. The impacts of dredging will be very similar to those discussed in an earlier section. The entire hot-spot area, including the contaminated wetland areas, would be dredged to remove sediments with elevated concentrations of PCBs and metals. The existing aquatic communities in these areas will be destroyed or disrupted, but in the long term more diverse and healthier aquatic communities will be established due to the uncontaminated environment.

The wetland areas may eventually reestablish themselves, but it will likely take decades to replace the approximate three feet of removed sediment at the current rate of sediment deposition. The recovery of these areas will possibly be hindered by development pressures to maintain waterfront properties and direct access to the estuary once it is cleaned up. The wetland areas currently serve as a buffer between the estuary and residential properties in Acushnet and Fairhaven.

The impacts of the temporary sediment storage area at the western cove will also be similar to those described under the in-harbor disposal site alternative. One difference is the additional use of this area to transfer dewatered sediments from the cove into trucks for transport to the disposal site. This operation will increase noise and nuisance conditions, and could result in airborne contaminants and general environmental contamination if spillage is not carefully controlled. The subsequent transport and disposal of the contaminated sediments are discussed in the next section.

Impacts of Upland Disposal

In a companion study to this report, potential upland disposal sites are being investigated. A key selection criterion was the environmental setting of the site with the objective of minimizing adverse environmental impacts. Sites that had potentially severe impacts on land, surface water, or groundwater resources were eliminated from further consideration. The sites eventually recommended for further study consisted primarily of wooded areas that are generally isolated from residential areas and have no access limitations.

Each proposed site is similar in size and thereby would displace, but not destroy, similar numbers of terrestrial animals. Similar types and areas of vegetation will be eliminated. One concern would focus on the metals since upland disposal will eventually dry and oxidize the sediments, thereby mobilizing the previously insoluble metals. The PCBs will continue to be bound to the sediments under these conditions. In general, the long-term environmental impacts will be minimized (if not eliminated) by the strict design requirements for a chemical landfill.

The principal impact associated with sediment transport via trucks is the potential for accidental spillage or leakage of water from the sediments along the haul route. Due to the location of the transfer point at the cove, at least part of the haul route must pass through heavily developed and populated areas. The extent of environmental contamination as a result of spillage or leakage will be limited by the use of leakproof transport vehicles, the restricted flow properties of the dewatered sediments, and the tendency of the contaminants to be immobilized within the sediment matrix.

8.2 Public Health Impacts

8.2.1 No-Action Alternative

Due to the magnitude and uncontrolled nature of the existing environmental contamination in the Acushnet River Estuary, the no-action alternative represents the highest level of risk to public health and welfare compared to the proposed remedial action alternatives. The potential pathways of human exposure to PCBs through the air, water, sediment, and biotic environments pose a persistent and accumulative risk for an indefinite period if no remedial action is taken. The ingestion of fish and shellfish from the estuary and harbor (despite the current ban) would continue to be a critical exposure pathway as the migration of contaminants from the hot-spot areas is sustained. The risk of a significant, near-instantaneous release of contaminants to the aquatic communities in New Bedford Harbor and Buzzards Bay is also posed by the sediments under extreme hydrologic and meteorologic conditions. A more detailed presentation of the public health impacts and risks associated with the no-action alternative has been provided in Section 3.3.

8.2.2 Hydraulic Control with Sediment Capping

The use of a double embankment channel with sediment capping should achieve complete isolation of the PCBs, heavy metals, and other pollutants in the estuary above the Coggeshall Street Bridge. This should, in turn, mitigate the public health concerns in the near-term and eliminate them in the long-term. Upon project completion the following conditions should be satisfied:

- The release of PCBs to the atmosphere and the related airborne contaminant exposure will be eliminated.

- The mudflat areas and sediments within the upper estuary will be covered by a clean cap so that direct contact with highly contaminated materials will be prevented. In fact, the present mudflats will no longer be inundated at high tide due to the increase in ground elevation caused by the cap.

- The contribution of contaminants to the food chain that initiates in the benthic organisms and bottom feeders will be eliminated.

The risk to humans posed by contaminated fish and shellfish will continue for a period of time until the organisms cleanse themselves through natural processes. The rate of depuration is species-dependent, and is being investigated in a companion study. It is expected that at least several years will be required before the heavily-contaminated species in the estuary will satisfy the current FDA level of 2 ppm for PCBs. This period of time will be lengthened for migratory species since sediments and the overall food chain below the Coggeshall Street Bridge will still be impacted by local contamination. Note, however, that the full channel will practically eliminate the downstream movement of some aquatic species.

The risk of failure posed by this alternative is low if the channel and sediment cap are properly engineered and constructed. Note, however, that the need to extend the channel into deeper portions of the estuary and the placement of an underwater sediment cap introduce particularly difficult engineering features to this alternative. The most likely failure mechanism would be an alteration of the sediment cap as a result of natural processes (e.g., extreme wind and wave conditions), future disruptions by individuals (e.g., unlawful dredging), or vandalism. The potential for a failure to the point of exposing the contaminated sediments is low, however, and the effects would be minimal due to the localized nature of a failure and the hydraulic isolation of these areas from Acushnet River flows. A breach of the embankment will likewise not have a significant health-related impact since contaminants in all contiguous areas will be covered and isolated by the cap.

Even though this alternative will not isolate the contaminants from the underlying groundwaters, the chemical nature of the PCBs and metals will inhibit their mobilization and transport into the groundwater system. If any migration does occur the related public impacts will be minimal since these groundwater zones are saline and do not currently have a consumptive use. The lateral subsurface movement of contaminants into shoreline areas will be reduced due to the hydraulic control and consequent reduction in the tidal prism.

The public health risks associated with construction activities will likewise be minimal. The sediments being covered by the channel or cap will be in a wet state throughout the construction period to minimize airborne releases. In addition, the proposed sheet pile barrier and silt curtain at the bridge opening and the localized use of silt curtains (if necessary) will reduce the risk of contaminant migration. Workers will be operating from land- or water-based equipment and will not be in direct contact with the sediments. Proper personal protection is readily available if deemed necessary, as for example dermal protection from splashing when operating in shallow water areas. Public access to the construction area would be prohibited.

8.2.3 Sediment Dredging with In-Harbor Disposal (Partially Lined Site)

The overall public health risks currently posed by the contaminated sediments will be similarly mitigated and/or eliminated under this alternative, with the exception that the contaminants are being removed with controlled disposal in this case rather than being simply isolated from the environment. As with the previous alternative, the risk of failure of the physical components will be low if properly designed and constructed.

The public health risk associated with the dredging and in-harbor disposal option is primarily related to contaminant migration both during and after project implementation. Proper sediment dispersal control will minimize the risk during dredging, while the embankment and site cap will provide effective migration barriers after project completion. Even a breach of the cap or embankment will not have catastrophic effects since the material is being stored in a partially dewatered state with reduced fluid properties, and the contaminants would tend to remain immobilized in the solids matrix.

Dredging or embankment construction in the highly-contaminated areas is expected to disturb PCB-laden oily films on the sediments. The dispersion of these substances can be at least partially controlled by silt curtains and absorbents or other types of techniques used for oil-spill control. Nevertheless, the presence of these films on the water surface would increase the potential for PCB dispersal and volatilization. Site operations must therefore include the periodic collection and disposal or treatment of any material or substance entrained by the dispersal control structures.

The need to temporarily store contaminated sediments in the western cove area in close proximity to residential, populated areas creates an increased risk of exposure. Because the temporary storage area must be constructed at least partially above the existing ground surface, a drying of the upper layers could occur over the period of temporary storage and would consequently increase the potential for airborne contamination.

The public health risks during construction will also be minimal and controllable for this alternative. The dredging operation itself, including sediment transport, dewatering, and disposal, will not require direct human contact with the sediments. Maintenance of the facilities could necessitate contact, but appropriate health and safety measures will minimize any associated risk. Public access to the disposal area will be prohibited during construction.

8.2.4 Sediment Dredging with In-Harbor Disposal (Lined Site)

The incorporation of a lined disposal site in the remedial action alternative will have both beneficial and adverse public health impacts in comparison with the partially lined alternative. On the positive side, a containment site having a bottom liner will obviously represent less risk due to the additional restriction on the vertical movement of contaminants. On the other hand, placement of the liner will require workers to operate within the dewatered area of the estuary.

8.2.5 Sediment Dredging with Upland Disposal

As with the in-harbor disposal options, this alternative will mitigate and/or eliminate the risk to public health currenty posed by the contaminated sediments by complete removal to an engineered and environmentally controlled upland landfill. The operational risks will be minimal for the dredging operation as previously explained, but will be increased relative to other options due to the need for temporary sediment storage and transfer on land in the vicinity of the western cove.

The upland disposal alternative also includes the additional public health risks of spills and leaks during transport. The upland disposal site itself will have synthetic liners to encapsulate the dredged materials and to prevent contaminant migration. In general, the long-term risk associated with the landfill is low. During the actual placement of materials in the landfill, the potential for direct contact with contaminated sediments will be maximized relative to the other alternatives. In addition, the material spread in lifts could quickly dry and become susceptible to airborne release. Metals may be leached if they are oxidized and solubilized in the landfill, but migration to offsite areas should be prohibited by the containment facilities.

8.3 Public Welfare and Community Impacts

8.3.1 No-Action Alternative

There have been some economic losses because of the official closure of the upper estuary to fishing, including reduced sports fishery and related activities (e.g., boat rental) and the costs to community residents resulting from the absence of a local catch in their routine diet. Other potential socioeconomic impacts that will be sustained under the no- action alternative include depressed property values in the vicinity of the harbor, the lack of impetus to redevelop the waterfront properties, and a reduced recreation value. A cost that cannot be estimated are expenditures for medical services for treatment of contaminant-related illness or other physiological effects caused directly or indirectly by the presence of PCBs and other contaminants in the estuary.

The principal economic effects of harbor contamination are associated with commercial activities in downstream areas. These were addressed in detail in

Section 3.4, and include the closure of the harbor to fishing and the taking of lobsters, constraints on development plans due to the cost of disposal of heavily contaminated dredge spoils, and the potential long-term effects of similar limitations on maintenance dredging. The latter would have drastic implications on the regional economy if harbor traffic cannot be maintained due to the gradual sediment build-up in the main shipping channel. A less obvious impact is the reported reluctance within the national fish market to purchase fish products from New Bedford due to the perceived relationship between the product and the environmental contamination (New Bedford Planning Department, 1984). This leads to direct costs for full-time personnel and expenses to market New Bedford products in order to counter these perceptions, and costs of lost markets that are more difficult to quantify in terms of harbor contamination.

The continued release of PCBs and metals to less contaminated downstream areas under the no-action alternative will perpetuate and exacerbate the existing conditions and associated impacts. As noted previously, it has been estimated that approximately 2,000 pounds of PCBs annually enter the inner harbor from the estuary about the Coggeshall Street Bridge.

8.3.2 Remedial Action Alternatives

Each of the four remedial action alternatives will remove or isolate the PCBs and metals in the Acushnet River Estuary upstream of the Coggeshall Street Bridge so that their transport to the harbor and bay is prevented. This will avoid the compounding of the contamination already in the harbor and bay, thereby reducing the exacerbation of public health, public welfare, and environmental impacts. Each alternative will likewise result in improved environmental and water quality conditions to increase property values and to promote recreational and other usage of the estuary.

An additional economic benefit that is common to all remedial action alternatives is the employment opportunities created by the projects. These opportunities would temporarily reduce unemployment in the New Bedford area, even though it would return to a pre-cleanup level when the project is completed. Long-term permanent employment may result from increased economic activity resulting from estuary cleanup, but these jobs would develop slowly and may not be of significant quantity. A related issue is the potential large demand for raw materials found within the general New Bedford area.

Adverse community impacts created by each of the alternatives are increased noise levels and fugitive dust emissions. Noise would be produced by construction, dredging, and transportation activities. Excessive noise levels can be expected to occur only periodically and in very localized areas of activity. Other than transportation, the only land-based activity that would produce persistent noise problems would be the transfer operation at the western cove if sediments had to be transported to an upland disposal site. Fugitive dust generated by construction activities may temporarily reduce air quality. However, the dust will primarily have its source in construction materials rather than the wet or dewatered sediments.

Other beneficial and adverse impacts are specific to one or several alternatives. Channelization of the estuary may adversely affect shoreline property values, particularly in Fairhaven and parts of Acushnet where the waterfront is part of privately-owned residential properties. The construction of the double embankment channel along the full length of the study area in the hydraulic control alternative would have the greatest impact since it would be directly opposite the residential waterfront properties in Fairhaven and would cut off direct access from the estuary to the downstream harbor. The devaluation of waterfront property would be offset somewhat by the restoration of the water quality and sediments in the upper harbor.

Another negative impact of channel construction is that the current discharges of treated effluent or non-contact process water to the estuary by waterfront industries will require either an extension of the outfalls to the new channel or a new tie-in (possibly requiring additional pre-treatment) to the New Bedford municipal wastewater collection and treatment system. At least a portion of these costs will be borne as part of the overall project costs.

The incorporation of an in-harbor disposal site will not physically impact on *waterfront properties since the wetland areas currently inhibit shoreline* development. If the land area created by capping the disposal site is converted to a protected wildlife habitat and park area, asocioeconomic benefit would be achieved to somewhat offset the perceived risk posed by the disposal area.

Adverse community impacts related to the use of an upland disposal area include increased truck traffic and related air and noise problems, increased maintenance of the primary haul roads, the likely need for an extension of utilities and services to the site, and the potential need for modifications to present zoning ordinances. Note that all the other alternatives have similar but lesser impacts due to the need to supply construction and capping materials.

With the possible exception of increased truck traffic, there should be no adverse impacts on community facilities such as schools, churches, hospitals, etc. None of the proposed alternatives are expected to impact cultural resources in the affected areas. No historic landmarks or other registered cultural resources are known to exist within the perceived impact zone.

8.4 Miscellaneous Cost-Effectiveness Measures

8.4.1 Level of Cleanup/Isolation Achievable

Under the no-action alternative, only natural mechanisms will act to reduce or isolate PCBs and heavy metals in the hot-spot areas. These include the slow chemical degradation of PCBs, uptake into the food chain, migration to other parts of the harbor/bay system, covering by clean sediments, and volatization or atmospheric release attached to airborne particulates. Only the chemical degradation can be considered as an acceptable removal technique among those identified. *Isolation caused by sediment burial has no significant negative impacts,* but the isolation may be temporary due to the vulnerability of the sediments to disruptive hydrologic and meteorologic forces.

Practically speaking, each of the remaining remedial action alternatives can be considered to achieve complete isolation and/or removal of the PCBs and metals from the hot-spot areas. A small percentage of the contaminants will remain in the sediments due to an inherent dredging inefficiency, and in some localized areas low levels of contaminants may be present at a depth below that dredged. The average concentration of PCBs remaining in the estuary sediments should, on the average, be less than the most stringent target value of 1 ppm. A similarly effective removal and/or isolation of heavy metals will concomitantly be achieved.

8.4.2 Acceptability of Land and Water Use After Action

Present constraints on the public, commercial, and recreational uses of the land and water resources will continue for an indefinite period under the no-action alternative. The hydraulic control and sediment cap alternative will significantly reduce the area covered by water, and the usage of even these areas would most likely be severely restricted in order to protect the integrity of the sediment cap. The land used for either an in-harbor or upland disposal site would preferably remain restricted to ensure proper monitoring and maintenance. The highly-visible central location of the in-harbor site would likely induce pressure for some level of use, and only a passive use such as wildlife refuge, conservation area, or park would be acceptable. Other uses such as a parking lot may be possible depending on the engineering properties of the dewatered sediments and cover materials.

It is important to recognize that additional dredging of contaminated sediments may be found in a subsequent feasibility study to be a cost-effective action for remediation of other portions of New Bedford Harbor. Disposal of these sediments will again be a critical issue. Any alternative in the present study that incorporates a provision for additional storage capacity should therefore be noted.

As depicted on Figure 7-6, the in-harbor disposal site could be expanded downstream to provide for additional storage. The upland sites are typically larger and have excess capacity, particularly considering that less constraints are imposed on the ultimate height of the upland landfill. The hydraulic control and sediment cap alternative provides no capacity for the disposal of additional contaminated sediments.

8.4.3 Time Required to Achieve Removal/Isolation

It is difficult to estimate the time required for the combination of natural processes to effect acceptable levels of contaminants in the Acushnet River Estuary. A crude estimate based on persistence levels and sedimentation would be several decades. In contrast, the estimated time required to achieve essentially complete removal and/or isolation by implementing a remedial action is as follows:

- Hydraulic control with sediment cap: 1.3 years
- Sediment dredging with in-harbor disposal: Unlined site - 2.7 years
  Lined site -5.3 years
- Sediment dredging with upland disposal: 3.5 years

These times represent actual construction times and may be approximately 25 percent longer to allow for appropriate planning and design, as well as to account for poor weather and logistical difficulties. Funding delays would obviously cause additional time requirements.

8.5 Estimated Costs for the Remedial Action Alternatives

Costs for the completion of each of the action alternatives were estimated and are presented as Tables 8-1 through 8-4. The costs do not include any additional long-term costs for groundwater or environmental monitoring programs.

TABLE 8-1
COST ESTIMATE
HYDRAULIC CONTROL WITH SEDIMENT CAPPING

Cost Element		Cost
Install Sediment Dispersal Control		$ 155,200
Construct Double Embankment Channel		7,534,500
Cap Sediments		7,733,000
Mobilization/Demobilization		20,000
	SUBTOTAL	$15,442,700
Health and Safety Monitoring		$ 617,700
Level D Working Conditions		133,300
Contingency		3,238,700
Overhead and Profit		1,943,200
Engineering		3,206,300
	TOTAL	$24,581,900

TABLE 8-2
COST ESTIMATE
SEDIMENT DREDGING WITH IN-HARBOR DISPOSAL
(PARTIALLY LINED SITE)

Cost Element		Cost
Install Sediment Dispersal Control		$ 155,200
Construct Temporary Containment Site		1,351,400
Dredge-dispose in Temporary Containment Site (beneath enbankment)		280,800
Construct Permanent Containment Site		3,039,500
Dredge - Dispose in Permanent Containment Site		4,146,100
Transport Sediments from Temporary Containment Site to Permanent Containment Site		104,000
Treat Water		2,288,800
Cap Containment Site		5,494,000
Mobilization/Demobilization		20,000
	SUBTOTAL	$16,879,800
Health and Safety Monitoring		$ 675,200
Level D Working Conditions		791,900
Contingency		3,669,400
Overhead and Profit		2,201,600
Engineering		3,632,700
	TOTAL	$27,850,600

TABLE 8-3
COST ESTIMATE
SEDIMENT DREDGING WITH IN-HARBOR DISPOSAL
(LINED SITE)

Cost Element		Cost
Install Sediment Dispersal Control		$ 155,200
Construct Temporary Containment Site		1,351,400
Dredge - Dispose in Temporary Containment Site		1,650,200
Construct Permanent Containment Site		31,523,241
Dredge - Dispose in Permanent Containment Site		3,749,800
Transport Sediments from Temporary Containment Site		611,200
Treat Water		2,983,700
Cap Containment Site		7,094,000
Mobilization/Demobilization		20,000
	SUBTOTAL	$49,138,700
Health and Safety Monitoring		$ 1,965,500
Level D Working Conditions		1,281,300
Contingency		10,477,100
Overhead and Profit		6,286,300
Engineering		10,372,300
	TOTAL	$ 79,521,200

TABLE 8-4
COST ESTIMATE
SEDIMENT DREDGING WITH UPLAND DISPOSAL

Cost Element		Cost
Construct Upland Containment Site		$ 6,369,500
Install Sediment Dispersal Control		155,200
Construct Temporary Containment Site		1,351,400
Dredge - Dispose in Temporary Containment Site		5,400,000
Transport Sediments from Temporary Containment Site to Permanent Containment Site		4,170,000
Treat Water		2,454,600
Cap Containment Site		6,769,100
Mobilization/Demobilization		20,000
	SUBTOTAL	$26,689,800
Health and Safety Monitoring		$ 1,067,600
Level D Working Conditions		1,226,800
Contingency		5,796,800
Overhead and Profit		3,478,100
Engineering		5,738,900
	TOTAL	$43,998,000

9.0 CONCLUSIONS AND RECOMMENDATIONS

A phased evaluation of technologies was used to evaluate remedial action alternatives, and five alternatives were retained for final evaluation in this fast-track Feasibility Study. The development and final selection of these alternatives were based not only on technical merit and cost-effectiveness, but also in response to uncertainties as to how the policy and regulatory framework governing any remedial action of the hot-spot areas would be interpreted and applied.

Table 9-1 has been prepared to summarize the alternatives relative to their potential impacts on the environment, public health, and public welfare. Short-term impacts are those that are in effect during the period of construction or for a short period of time afterwards. The latter would include, for example, the re-establishment of the aquatic community after dredging. Long-term impacts can be thought of as permanent since they are associated with irreversible changes to the study area. As indicated on the figure, serious public health, public welfare, and environmental problems and impacts would persist under the no-action alternative. For this reason, the no-action alternative is not recommended for the hot-spot areas. Inclusion of the no-action alternative in the final analysis has, however, provided an assessment of the current problem and impacts for use as a comparative baseline in the evaluation of the remaining alternatives. This is of particular value when each of the other alternatives has associated short-term and/or permanent impacts that jeopardize its ultimate acceptance by permitting agencies and the general public.

Each of the remedial action alternatives (less the no-action alternative) is considered to be technically feasible and responsive to the study objectives. The chemical behavior of PCBs is particularly compatible with the isolation and containment schemes proposed. PCBs do not appreciably solubilize in water, they are strongly adsorbed onto solid particles such as organic and silty sediments, and they undergo only a limited volatization.

The alternative of hydraulic control and sediment capping is the only option which isolates rather than removes the contaminated sediments. This option is the least costly of those evaluated, and reduces the potential for resuspension of the contaminants and the associated risk when compared to the dredging alternatives. The beneficial effects of isolating the contaminants must be weighed, however, against the resultant permanent alteration of the hydrology and aquatic resources of the estuary above the Coggeshall Street Bridge. The principal negative impacts include permanently inhibiting a free tidal exchange through the bridge opening, partially filling wetlands by the sediment cap, totally prohibiting access to the lower harbor from above the bridge, altering fish migration routes and eliminating migration access to the remaining open water areas above the bridge, and decreasing waterfront property values. The need to extend the channel into the deeper portions of the estuary near the bridge opening and the placement of an effective underwater sediment cap introduce particularly difficult engineering features to this alternative. As a result, the long-term integrity of the isolation alternative may be reduced in comparison to the removal options. An additional negative feature is that the potential future need for the disposal of contaminated sediments from the lower harbor cannot be incorporated into this alternative.

The two dredging and in-harbor disposal alternatives achieve the study objectives by the physical removal of the sediments to an engineered and controlled environment. Such alternatives are more consistent with the objective to achieve a permanent remedy to prevent or mitigate the migration of contaminants and the associated risk. Numerous short- and long-term adverse impacts do exist for these alternatives, however. The most noteworthy are the permanent loss of wetlands and an increased potential for contaminant resuspension and migration during the active site operations.

The use of a liner would both reduce the potential risk of leakage from the disposal site and increase the acceptability of this alternative. These advantages would be offset, however, by actual and potential adverse impacts associated with the temporary storage of additional contaminated sediments in shoreline areas (e.g., the cove on the western shore) and the initial dewatering. The placement of a sand blanket (for bearing support) and liner over the extensive disposal area (approximately 60 acres), in addition to the initial dewatering of this area and the development and operation of a temporary storage site, result in an estimated threefold increase in costs relative to the unlined disposal area alternative ($79.5 million versus $27.9 million).

The use of an upland disposal site eliminates many of the critical environmental impacts of the other alternatives, but introduces many new environmental, public health, and community impacts. This alternative potentially involves the removal of the contaminated sediments to new and uncontaminated areas and communities that are not directly affected by the hot-spot areas. This not only severely reduces the overall acceptability of the option, but may introduce a more stringent interpretation of the regulations for waste generation, hauling, and disposal than that associated with "onsite", in-harbor disposal and control of the contaminated sediments.

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APPENDIX A

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APPENDIX B

INITIAL SCREENING OF REMEDIAL ACTION TECHNOLOGIES

DRAFT

APPENDIX B

TABLE OF CONTENTS

APPENDIX B

TABLE OF CONTENTS (continued)

APPENDIX B

TABLE OF CONTENTS (continued)

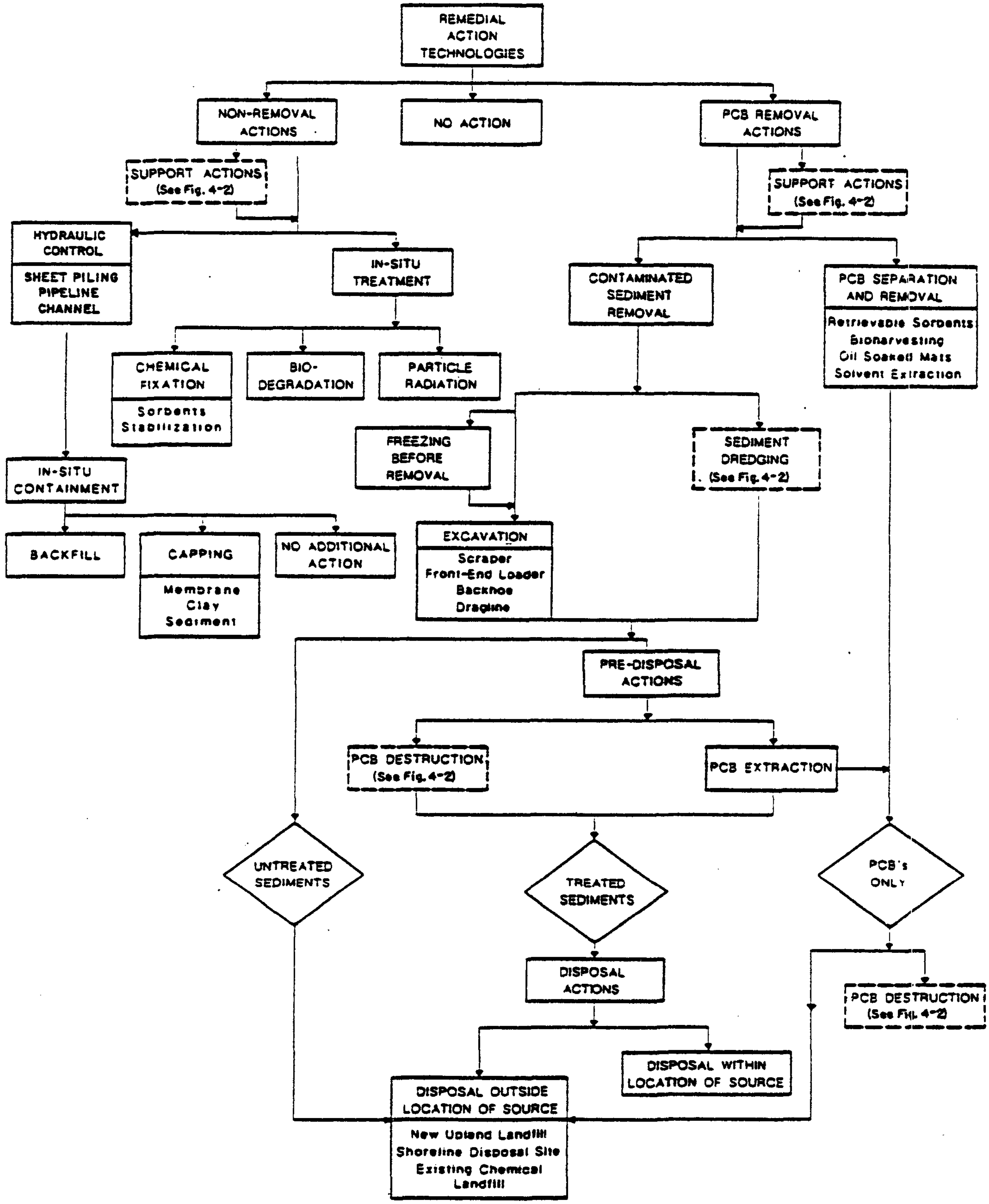
DRAFT

APPENDIX B

TABLE OF CONTENTS (continued)

INTRODUCTION

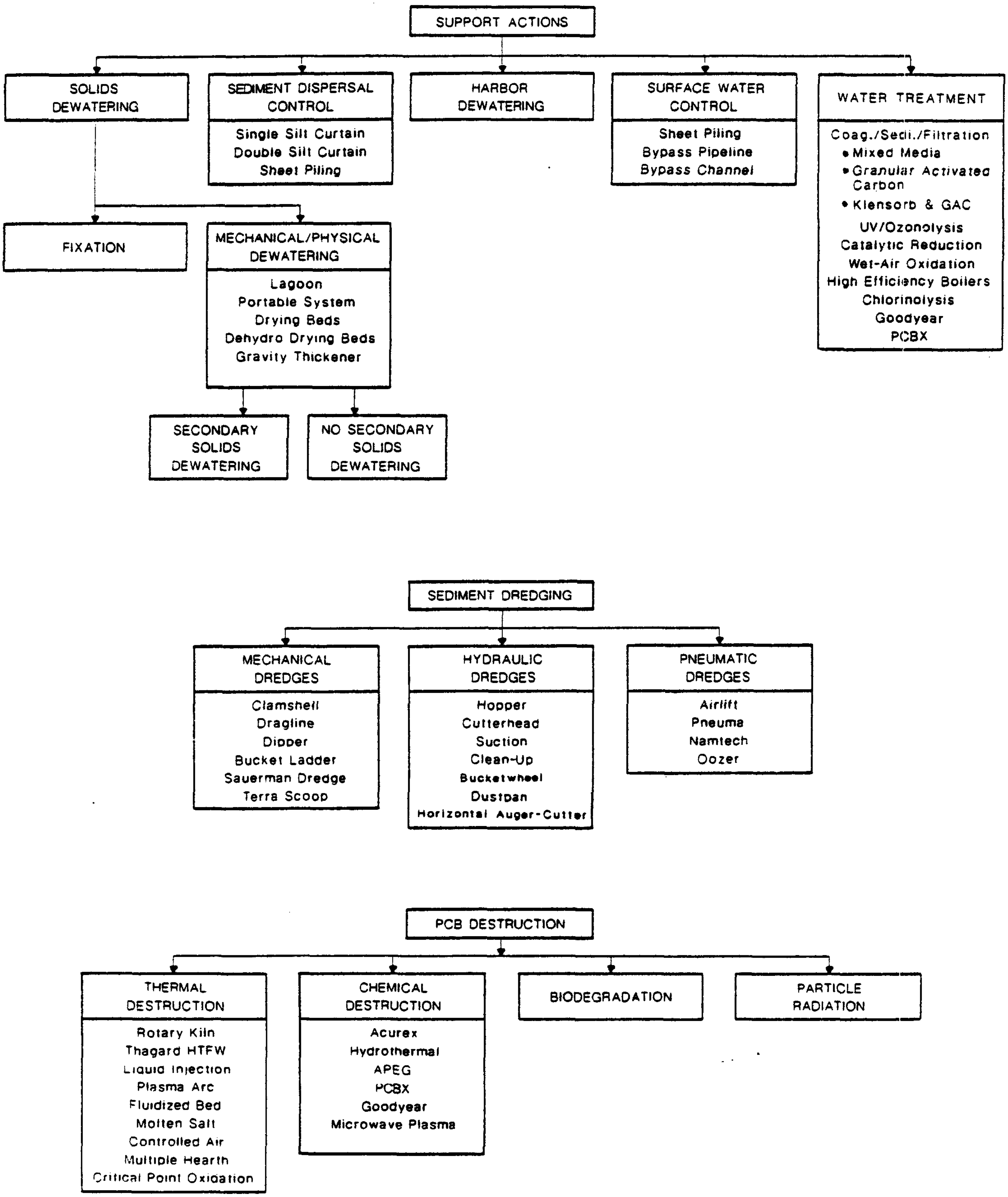
Appendix B provides an extended description of each technology evaluated during the initial screening of remedial action technologies in Section 4.0. The information contained in Appendix B has been ordered to track various combinations and sequences of technologies as they relate to remedial action alternatives. Figures 4-1 and 4-2, which illustrate these combinations and sequences, have been reproduced on the following pages for convenience purposes.



TECHNOLOGIES/ALTERNATIVES IDENTIFIED
FOR PRELIMINARY SCREENING PROCESS
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

FIGURE 4-1

NUS CORPORATION
A Halliburton Company



TECHNOLOGIES/ALTERNATIVES IDENTIFIED
FOR PRELIMINARY SCREENING PROCESS
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

FIGURE 4-2

NUS CORPORATION
A Halliburton Company

Non-Removal Actions

Hydraulic Control

Description: This alternative involves the construction of hydraulic structures to eliminate both Acushnet River freshwater inflows and tidal fluctuations in the hot-spot areas of the upper harbor. The objective is to minimize water contact with the contaminated sediments, and to prevent their transport to the lower harbor and bay. A pipeline or open channel structure would be devised to convey Acushnet River flows directly from uncontaminated upstream areas to a point below the Coggeshall Street bridge. Tidal flows would be controlled by integrated structures at the reduced openings of the Coggeshall Street or I-195 Bridge.

Technology Status: Hydraulic control structures represent commonly used construction practices.

Conclusions: This alternative will be retained for further consideration.

In-Situ Containment

Backfill

Description: This technology requires backfilling of the upper harbor following construction of the hydraulic control structures. Common fill could be placed, or the isolated estuary could be utilized as a containment site for PCB-contaminated sediments removed from the lower harbor or Buzzard's Bay. Capping of the site would be required if a containment site is developed.

Technology Status: This technology requires common and straightforward construction practices.

Conclusions: This alternative will not be considered further because of the prohibitive environmental and community impacts resulting from backfilling the upper harbor.

No Additional Action

Description: This alternative assumes that hydraulic control of the upper harbor will be implemented, and the contaminated sediments will not be treated or removed. Stagnation of the upper harbor would occur and a major health problem may result because insect reproduction could become excessive, and industrial outfalls would continue to discharge into the water.

Technology Status: Not applicable.

Conclusions: This alternative shall not be considered further due to potential adverse health effects.

Capping

- **Fabric Cap**

Description: This alternative entails placing a woven fabric cap over the contaminated sediments. Since the cap is constructed of woven material, it would allow gases formed by biological activity underneath it to escape while still stabilizing the sediments. However, the fabric does not have an infinite lifespan in the environment. Also, construction of the fabric cap would not be feasible because fabric placement and sewing would be impractical underwater. Therefore, dewatering of the harbor would be required for this alternative.

Technology Status: This technology has not yet been extensively applied to dynamic aquatic environments.

Conclusions: This alternative shall be retained for further consideration.

- **Clay Cap**

Description: This alternative involves the construction of an impermeable clay cap on top of the contaminated estuarine sediments. In order to construct the cap by typical engineering practices, the estuary would require dewatering to expose the contaminated deposits. Extensive dewatering of the sediments might be required in order to assure subbase stability. Clay would then be placed and compacted over the entire bottom of the estuary. Very soft deposits might require stabilization in order to support the cap material and subsequent compaction equipment.

Technology Status: Clay capping of hazardous substances is a commonly used technology in dry environments.

Conclusions: This alternative will be retained for further evaluation, although dewatering will be required.

- **Sediment Cap**

Description: The covering of contaminated sediments with clean, fine sediments has been utilized on projects in both Japan and the United States. An extensive study on this technique was conducted on a project in the New York Bight beginning in 1980.

Results indicated that cap erosion under normal meteorologic conditions was minimal, but that major storm events could cause extensive erosion. It was also determined that the cap had positive effects on the reduction of bioaccumulation rates.

This technique, however, has not been proven in shallow waters, where wind and wave action has a major effect on shallow sediments.

Technology Status: Sediment capping of contaminated materials is a new technology, but it has been proven in several applications.

Conclusions: This alternative will be retained for further evaluation.

In-Situ Treatment

Particle Radiation

Description: Particle radiation can be used for the destruction of wastes. PCB destruction is completed in a stepwise manner using the electron beam or gamma radiation processes. Sufficient doses of gamma radiation can carbonize PCBs, leaving no trace of the original pollutants. Similar results are noted using electron beams produced at lower energy levels. A cost effective approach to the use of radiation technologies for sediment decontamination would be their use as an in-situ detoxification process, although there are no reported plans to develop such a process.

Technology Status: The use of particle radiation as a PCB destruction technique for contaminated sediments is still in the early development stage.

Conclusions: The preliminary state of the technology for radiation destruction of PCBs precludes the further evaluation of this alternative.

Biodegradation

Description: Biological destruction of PCBs in sediments has produced only limited success during its development. Existing biological agents (microbes, worms) are capable of using PCBs as their sole source of carbon, but only the lesser chlorinated biphenyls (1-5 chlorines) degrade readily. The highly chlorinated biphenyls (6+ chlorines) undergo negligible degradation.

Commercial PCBs are not a single compound, thus making the potential for biodegradation difficult to evaluate. There is no single micro-organism that will oxidize all of the PCB Aroclors.

Technology Status: This technology is not viable for in-place applications in an uncontrolled environment.

Conclusions: Biodegradation has been eliminated from further consideration because of its technology status. A feasible method has not been found for the large-scale application of the biological agent.

Chemical Fixation

- ***Sorbents***

Description: Sorbents can be used for the in-place fixation of organic contaminants in sediments. Adsorbent materials, such as activated carbon, have large surface area to volume ratios that permit effective uptake of PCBs. An alternative for the stabilization of the PCBs in the New Bedford Harbor would involve the addition of activated carbon to the sediments as a slurry. Because the PCBs would have a greater affinity for the sorbent than the sediments, PCB interchange with the environment would be reduced.

Problems associated with this alternative are that some areas are more highly contaminated than others; thus some areas may not receive enough sorbent to adsorb all of the contaminants; and the material would remain on the harbor bottom, lending itself to eventual desorption.

Technology Status: The technology associated with the application of sorbents to harbor sediments uses current engineering practices.

Conclusions: Sorbents as an alternative will not be evaluated any further because a significant percentage of the PCBs might remain unfixed on the harbor bottom.

- **In-Situ Stabilization**

Description: Contaminated sediments can be solidified by pumping a mixture of portland cement and proprietary reagents into the deposits. The mixture traps the sediment particles in an insoluble silicon hydroxide matrix. A vertical column of stabilized material is produced; the process is then repeated in the adjacent portions of the sediment bed.

This technique may be difficult to implement since it is difficult to assess how deep or how thoroughly the stabilizing agents penetrate the sediments. In addition, the long-term stability of the stabilized sediments has not been evaluated.

Technology Status: Stabilization has been successfully applied to contaminated sediments and waste residues (with low organic contents), but not for areas as large as that under consideration and not in such dynamic aquatic environments. The technology has not been effective on materials with high organic contents.

Conclusions: Due to the technology status, this alternative has been eliminated from further evaluation.

No Action

Description: This alternative assumes that no remedial action will be taken, and PCBs and heavy metals will remain in sediments and surface waters. No immediate capital expenditures would be required under CERCLA. However, socioeconomic impacts may include

- Loss of commercial fishing industry.
- Loss of finfish and shellfish for human consumption.
- Risk of human exposure.
- Reduced property value.
- Continued impact on harbor development projects.
- Reduced recreational value of surface waters.
- Adverse effects on public welfare.
- Increased expenditures for environmental monitoring and laboratory analyses.
- Continued transport of significant quantities of PCBs to New Bedford Harbor and Buzzards Bay.
- Continued moratorium on harbor dredging.
- Continued damages to natural resources.

Technology Status: Not Applicable.

Conclusions: The no action alternative will be considered during future screening.

PCB Removal Actions

Possible PCB removal actions for the contaminated sediments include removal of the PCBs from the harbor sediments, or removal of the contaminated sediments themselves. Assuming that the PCBs were to be removed from the sediments, the action would be followed by either PCB destruction or PCB disposal into an approved landfill. If the contaminated sediments were removed from the harbor, either excavation or dredging practices would be used. Predisposal actions, such as PCB destruction or extraction, could then be applied to the sediments. If no pre-disposal action is used, the contaminated sediments would be disposed directly into an approved landfill. An additional disposal option for properly decontaminated sediment is a controlled release back into the harbor.

Contaminated Sediment Removal

Freezing Before Removal

Description: In this method, refrigeration probes are inserted into the sediments and then are cooled by a portable refrigeration unit. Porewater within the permeable soil is frozen, and the frozen sediment blocks can be removed with minimal disturbance to the remaining sediment. Each probe can freeze a zone of sediment approximately 1.5 feet in diameter.

Technology Status: Never applied to an area as large as that under study.

Conclusions: This procedure would not be suitable for use over a large area. Therefore, this alternative has been eliminated from further consideration.

Excavation

- **Scraper**

Description: A scraper is both an excavating and a hauling device. As the unit is moved forward, the bottom-loading pan removes surficial soils (generally to depths of less than one foot) and collects them within the scraper body. The scraper, which can be either towed or self-propelled, can then transport the contaminated material to a transfer station or disposal site. Scrapers can excavate soil at between 30 and 100 yd^3/hr.

Relatively dry soil conditions are required for proper operation. Another disadvantage to the scraper is the possibility of uncontrolled transport of contaminated material on the scraper tires, as the unit must travel onto the contaminated area in order to remove and transport the soil.

Technology Status: Excavation and hauling with scrapers is a widely used and well established practice.

Conclusions: The scraper will be removed from further consideration, since excessive dewatering, which would be required for proper operation, would be extremely difficult to achieve in an in-situ condition. Also the sediments will not provide adequate bearing support for the equipment unless costly support actions are implemented.

- **Front End Loader**

Description: A front end loader is an excavating/loading device which is composed of a tractor and front-mounted bucket. Soil is collected in the bucket, and then raised for dumping into trucks or other modes of transportation. Relatively dry soil conditions are required for operation. Front end loaders have an average excavation rate of between 70 and 180 yd^3/hr.

Technology Status: Excavation and loading with front end loaders is a widely used and well established practice.

Conclusions: The front end loader will be removed from further consideration. Although its use is well established, the thick, unconsolidated sediment deposits will not provide adequate bearing support for this equipment unless very costly support actions are implemented. Harbor dewatering would be necessary but would be inappropriate for technical reasons.

- **Backhoe**

Description: A backhoe is an excavation device composed of a hinged arm with a bucket attached to the free end. Large backhoes are capable of excavating to maximum depths on the order of 30 feet and at rates of up to 150 yd^3/hr. This type of equipment is technically suitable for the excavation of wet materials.

Technology Status: The backhoe has been commonly used in many applications.

Conclusions: Backhoe excavation shall be removed from further evaluation, because dewatering of the sediment areas will be required and the sediments also would not support this equipment.

- **Dragline**

Description: A dragline can be used for the excavation of exposed sediments, and is quite suitable for the removal of wet soils. Small draglines have an average production rate of between 30 and 110 yd^3/hr; larger draglines, such as those used in strip mining operations, are capable of much higher production rates, but may not be practical to mobilize for this site.

Technology Status: Dragline excavation is a well established and commonly used practice.

Conclusions: The dragline will be removed from further evaluation, for the same reasons as those given for a backhoe, front end loader, and scraper.

Sediment Dredging

- **Mechanical Dredges**

  - **Clamshell Dredge**

Description: A clamshell dredge uses a bi-parting bucket to collect/remove subaqueous earth materials. The bucket and contents are raised and the contents dumped into barges or trucks for transportation to the location of final disposition. Conventional clamshell buckets may lose between 15 and 50 percent of the contained sediments during the raising of the bucket. Watertight clamshell buckets which reduce such losses are available. Location and depth of the bucket excavation are not easily controlled, and PCB removal efficiency can be quite varied. An advantage of clamshell dredging is that removed sediments may not require fixation or dewatering before disposal.

Technology Status: Clamshell dredges have been in wide use for several years.

Conclusions: This alternative was retained for further evaluation, although the potential resuspension of contaminated sediments is a significant drawback.

  - **Dragline Dredge**

Description: A dragline dredge operates by pulling a bucket through the sediment and back towards the rig. The bucket is then raised and the sediments dumped into barges or trucks. Average production rates of dragline dredges are slightly less than those of the clamshell dredges. This type of dredge requires a large amount of open space for movement during operation, and also causes considerable sediment suspension.

Technology Status: Dragline dredging is a well-established process.

Conclusions: Since the process could result in the suspension of highly contaminated sediments, dragline dredging has been removed from further consideration.

- **Dipper**

Description: A dipper is composed of an articulated arm with a bucket attached to the free end. Sediments are scooped with the bucket, and then raised out of the water. Greater sediment dispersion is caused by this method than by most other mechanical dredging techniques.

Technology Status: This is a previously demonstrated technology but it has not been used in applications with contaminated sediments.

Conclusions: The dipper has been removed from further consideration, since the process could result in a high degree of contaminated sediment dispersion.

- **Bucket Ladder**

Description: A bucket ladder is composed of a continuous chain with attached buckets to reach into the sediments which are to be dredged. The buckets scoop sediments and carry them to the surface in a continuous motion. Dredged materials are then transferred to a conveyor or chute, which in turn transport the sediments to a barge or truck. Severe disturbance and suspension of contaminated sediments can be expected with this method.

Technology Status: The bucket ladder is used extensively in Europe and also for commercial applications in the U. S.

Conclusions: This method has been removed from further consideration due to the large amount of contaminated sediment that would be suspended.

- Sauerman Dredge

Description: A Sauerman dredge utilizes an overhead cable, supported on one end by a tower and on the other by a deadman. A horseshoe-shaped bucket, which is used to scrape the sediments into a pile, is suspended from a pulley which runs on the cable. Since the cable is slanted downward towards the deadman, the bucket and pulley assembly can be moved across the water by gravity. After being lowered into the water, the bucket is then pulled toward the crane with a tagline, and the sediments piled for subsequent removal. This procedure severely disturbs and suspends the bottom sediments.

Technology Status: This is a previously demonstrated technology but it has not been used in applications with contaminated sediments.

Conclusions: Since the process could result in the suspension of highly contaminated sediments, the Sauerman Dredge has been removed from further consideration.

- Terra Marine Scoop

Description: This system uses a scoop-shaped bucket to scrape sediment from the harbor bottom. A set of steel cables is connected to a truck-mounted winch on one end of the harbor; and to a deadman on the other. The cables are extended across the water body to be dredged. The bucket is pulled through the sediments, and is then dumped when it reaches the opposite bank. It is expected that the procedure would be slow, and would result in the resuspension of large amounts of fines.

Technology Status: This is a previously demonstrated technology but it has not been used in applications with contaminated sediments.

Conclusions: This technology has been removed from further consideration, since the process could result in a high degree of contaminated sediment suspension.

- **Hydraulic Dredges**

  - Hopper Dredge

Description: The hopper dredge is a self-contained ship that uses a suction pump to draw sediments into hopper compartments within the vessel. Sediments are collected by a suction head, and then are drawn through piping to the hoppers. When the hoppers are full, the dredge travels to a discharge location, and the sediments are pumped out of the hoppers to either a landfill/lagoon or a means of further transportation. Operation of the hopper dredge would require extensive maneuvering space. The sediment slurry would require dewatering, and the slurry water would have to be treated. Sediment suspension would be low to moderate, although some sediment dispersal control might be required.

Technology Status: Originally used for ocean operations, the hopper dredge is now being used for shallow water applications as well.

Conclusions: The hopper dredge has been retained for further evaluation.

- Cutterhead Pipeline Suction Dredge

Description: Cutterhead suction dredges use rotating, circular cutter blades at the end of a suction pipe, which are suitable for the dredging of materials varying in size from fine silts to decomposed rock fragments. A shroud can be attached to the top of the cutterhead in order to reduce sediment dispersion. The cutterhead could be eliminated entirely, in order to reduce dispersion, but this would allow the removal of only loose, unconsolidated sediments. A disadvantage of this method is the requirement for a floating or submerged pipeline to transfer the sediments to a disposal or transportation area. These pipelines require approximately one booster pumping station for each mile of pipe, and could introduce significant costs to the process.

Technology Status: Cutterhead suction dredges are very widely used.

Conclusions: The cutterhead suction dredge has been retained for further evaluation.

- Suction Dredge

Description:

A suction dredge removes sediments hydraulically from the harbor bottom, and discharges the materials through a floating pipeline. It is similar to a cutterhead dredge except for the absence of the cutter. Water jets can be attached to the head in order to loosen dense sediments. Floating pipelines and booster pumps could become a major cost item.

Technology Status: Suction dredges have been used for several applications, and tests are being conducted on their suitability for contaminated sediments.

Conclusions: The suction dredge will be retained for further consideration.

- Clean-up Dredge

Description: The clean-up dredge consists of a hydraulic suction dredge with a modified suction head. The modified head can deflect currents generated by the suction, and can collect gases released during the dredging process. Monitoring equipment is also utilized during operation.

Technology Status: The Clean-up dredge was developed in Japan, and apparently has not been used in the U.S.

Conclusions: As a modified cutterhead type, the clean-up dredge has a relatively low production rate; therefore, this alternative has been eliminated from further evaluation.

- **Bucketwheel Pipeline Suction Dredge**

Description: The bucketwheel excavator serves both the dredging and the mining industry. It will excavate soft fine grained material, including clay, and hard compacted material, including gravel and ores. The bucketwheel is a rotating wheel excavator consisting of bottomless buckets which force-feed dredged material into a receiving hopper contained within the rotating wheel. The hopper directs the excavated material to the dredge suction pipe for hydraulic transport. The bucketwheel produces a dense slurry at a constant rate and effectively cleans-up the bottom.

Technology Status: Recent extensive research and development within the United States has produced an effective bucketwheel dredge with commendable features. This dredge is widely used in the United States and several foreign countries.

Conclusions: The bucketwheel suction dredge has been retained for further consideration.

- Dustpan Dredge

Description: A dustpan dredge uses a suction head that is shaped like a dust pan; water jets are mounted on the cutting edge of the head in order to loosen stiff sediments. The dredges are suitable for removing sediments in a path up to 36 feet in width.

Technology Status: Dustpan dredges are in regular use on the lower Mississippi River for maintenance dredging.

Conclusions: This alternative has been retained for further evaluation.

- Horizontal Auger - Cutter Dredge

Description: A horizontal auger-cutter dredge uses a hydraulically operated boom to lower an auger-cutter assembly into the sediments. The sediments are first loosened and then delivered to a pump suction intake by the auger-cutter assembly. The slurry mixture is conveyed to a remote location, such as a settling basin, for dewatering and final disposition. Larger models are suitable for dredging at depths of up to 15 feet.

Technology Status: Horizontal auger-cutter dredges are widely used, particularly for shallow water areas where maneuverability of larger equipment is restricted.

Conclusions: The horizontal-auger-cutter dredge has been retained for further evaluation.

- Pneumatic Dredges

  - Airlift Dredge

Description: The airlift dredge operates by forcing compressed air into the lower end of a vertical conveying tube. An upward movement of the water in the conveying tube results, due to the decrease in water density (within the tube). This vertical movement acts as suction on the sediments and causes the conveyance of the solids. The sediments are transported to the surface through the pipe, and then are discharged into a recovery barge. An airlift dredge is suitable for sand and gravel deposits, and for deep deposits; in practice, depths of up to 300 feet have been reached.

Technology Status: Airlift dredges are not commonly available equipment; generally the dredge is manufactured for a specific purpose. Accordingly, experience with this dredge is expected to be somewhat limited.

Conclusions: The airlift dredge has been retained for further evaluation.

  - Pneuma Dredge

Description: The Pneuma dredge uses a two-stage vacuum suction system for the removal of fine-grained sediments of near in-situ densities. This dredge, which was designed overseas for the purposes of toxic waste removal and lake reclamation, is not suitable for shallow deposits.

Technology Status: Only three units are available in the U. S., and use of the Pneuma dredge is expected to have been minimal.

Conclusions: This alternative has been eliminated from further consideration due to limited availability. Also, it is not suitable for use in shallow deposits.

- <u>Namtech Dredge</u>

Description: The Namtech dredge operates on the same principle as the airlift and Pneuma dredges. Pumping at up to 40 percent solids may be possible with the unit. The dredge has been tested under EPA approval, and more information should be available in the near future.

Technology Status: This dredge has been manufactured in the U. S., but operational data is limited.

Conclusions: This alternative has been retained for further evaluation.

- <u>Oozer Dredge</u>

Description: A Japanese dredging system has been developed that combines vacuum suction and air compression to remove sediments. The Oozer dredge is favorably viewed by the Corps of Engineers, and is considered effective in controlling turbidity. However, this system is not currently available in the United States.

Technology Status: All work with the Oozer dredge has taken place overseas; the technology status is presently not well documented.

Conclusions: The Oozer Dredge has been eliminated from further consideration due to limited availability. The requirements for the dredging of the harbor can be met by more readily available equipment.

Pre-Disposal Actions

PCB Extraction

Description: This process would involve the extraction of PCBs from the dredged sediments, thus permitting the disposal of the sediments as a non-hazardous material. PCB-contaminated solvents would then be incinerated in a licensed facility or shipped to an approved hazardous waste landfill. The extraction could be accomplished using commercially available equipment, although such a use would be considered unconventional. At the present time, there are no EPA demonstrated methods for the extraction of PCBs from contaminated sediments or soils. It appears as though the extraction process would increase the volume of material to be treated, and as a result PCB destruction may incur large capital and operating expenses possibly increasing treatment costs with respect to other options.

Technology Status: PCB extraction is a new application of existing extraction principals and methods. At this time, there are no EPA demonstrated methods for the PCB extraction of contaminated sediments and soils.

Conclusions: Since no PCB extraction process has been demonstrated, National Contingency Plan requirements preclude this technology from further examination.

PCB Destruction

- **Thermal Destruction**

Destruction of contaminants in soils or sediments can be accomplished with the use of a mobile incinerator. The incinerator must meet federal requirements, which state that the incineration of contaminated materials must only be done at steady-state operating conditions, and all wastes must be analyzed before incineration to determine the PCB content and the concentrations of metals in the sediments. All

EPA and Massachusetts monitoring requirements must also be met. Incineration methods considered for use for this site are rotary kiln, Thagard HTFW, liquid injection, plasma arc, fluidized bed, molten salt, controlled air, multiple hearth incineration, and critical point oxidation.

- Rotary Kiln Incinerator

Description: The rotary kiln is a high temperature PCB destruction technique currently available to the market. Two facilities have EPA permits (Texas and Arkansas) to operate incinerators in the 1800 - 2,200°F temperature range. In addition, a test by the EPA is underway using a mobile rotary kiln that will operate at a temperature of 2,200°F.

Technology Status: Rotary kiln incineration is the only incineration process for contaminated sediments and soils that has been approved by EPA. Mobile or stationary units are currently available, and with little modification can be readied for sediment decontamination.

Conclusions: An EPA permit would be required for rotary kiln incinerators to be used on site. Transportation of large volumes of sediments to incinerators in Texas or Arkansas would create large economic burdens. The use of this system is feasible, however, and the rotary kiln incinerator will be retained for further evaluation.

- Liquid Injection Incinerator

Description: A liquid injection incinerator would be used to decontaminate PCB-contaminated solvents after they have been used to extract the PCBs from the dredged sediments. A system that could be used for this process would include the extraction of the soils and recovery of the extract, concentration of the extract by distillation (by this method the solvent could then be reused), and liquid injection incineration of the distillate bottoms. The incinerator achieves destruction percentages upwards of 99%.

Technology Status: Liquid injection incineration is one of the most widely used incinerators for the destruction of hazardous wastes. Incineration units are easily obtainable and manufacturers can readily supply all of the necessary technologies.

Conclusions: Although this incineration method could prove to be the most economical means of PCB destruction, the fact that the Solvent Extraction was previously eliminated precludes the use of Liquid Injection Incineration.

- Thagard HTFW

Description: Thagard Research Corporation has developed a high-temperature, fluid wall reactor (HTFW) that completely pyrolyzes PCBs, and fixes the residues into nonleachable glasses. This reactor maintains a high temperature (4,000°F) by radiant heat emanating from a gaseous fluid envelope (generally nitrogen). It operates without catalysts, and is thus unaffected by impurities in the feed (water, sulfur, metal). Laboratory tests using hexachlorobenzene (HCB) as a surrogate for PCBs showed a destruction order of 99.9999 percent upon a 0.1 second reaction time.

Technology Status: Testing of this process is still being done at the laboratory level.

Conclusions: The destruction of PCBs using a high-temperature, fluid wall reactor will not be evaluated any further, because of its laboratory status.

- Plasma Arc Incinerator

Description: The plasma arc process is a technique developed for PCB solids destruction which dechlorinates by molecular fracture. The plasma arc is produced by a low-pressure gas through which an electric current (arc) is passed. The by-products that result from passing PCBs through this arc are simple chlorine, hydrogen, and carbon atoms. This process is expected to work on contaminated sediments, and has the advantage of not requiring a solvent extraction of the solids. The development of a soil/sediment facility is still in the future, with the expectations of an energy-efficient process.

Technology Status: Plasma arc incineration is a preliminary process that is still in the early stages of laboratory development. This process involves the use of new technologies for which a high degree of testing will be required before operational models are produced.

Conclusions: Because of the early stage of development and the technical status of the process, plasma arc incineration will not be evaluated further.

- **Fluidized Bed Incinerator**

Description: PCB destruction is obtained with this method at a temperature of 1250°F using a chronic oxide and aluminum catalyst. Rockwell International's (the developer) fluidized bed incinerator recently underwent a successful one-gallon test burn of PCBs (at 700°F) for the EPA. Although this process has proven useful for PCB destruction, there are no reported plans to develop this system any further, or to use it in connection with contaminated sediments.

Technology Status: Although fluidized bed incineration is a well developed technology, its application to hazardous wastes--specifically PCB contaminated sediments--is still considered developmental.

Conclusions: Fluidized bed technology has been a long proven process for waste incineration, although its direct application to PCBs remains uncertain. Because a PCB incineration process is not being developed at this time, this process will not be evaluated further.

- **Molten Salt Incinerator**

Description: The molten salt incineration process, demonstrated by Rockwell International, destroys PCB waste by injecting a mixture of the waste and air into a sodium carbonate/molten salt mixture at 1450°F to 1800°F. A portable incinerator rated at 225 pounds per hour is available. Very good results have been achieved for PCB removal using this method, but this system has not been recommended by Rockwell for use with organic river sediments (a high ash material) due to the high flow requirements needed for transport through the sodium carbonate solution.

Technology Status: This technology is currently being developed as a spin-off of a process development for coal gasification. Developmental efforts are not focused towards a PCB destruction application, so process development may be slow.

Conclusions: The availability of this process does not appear probable in the near future, and the molten salt incinerator will not be evaluated further.

- **Controlled Air Incinerator**

Description: The Los Alamos National Laboratory has modified a controlled-air radioactive waste incinerator to burn PCB waste. The incinerator is a conventional dual-chamber, controlled-air design with operating temperatures for PCB destruction ranging from 1,600°F (Chamber No. 1) to 2,000°F (Chamber No. 2). Attempts are currently underway to obtain a permit for a PCB test burn. However, the state of development renders this process unsuitable for near-term use on contaminated sediments.

Technology Status: The use of a controlled air incinerator for PCB destruction is still under development, and much more testing will be required before approval is given for sediment decontamination.

Conclusions: Because a full scale use of this process for sediment decontamination appears to be uncertain at this time, it was removed from further evaluation.

- Multiple Hearth Incinerator

Description: Multiple hearth incinerators were originally developed for the treatment of sewage sludges, but have recently been applied to the treatment of various types of industrial wastes. Test burns have been conducted on mixtures of pesticides and PCBs with sewage sludges, and have resulted in high destruction ratios.

Technology Status: Multiple hearth incineration technology is well developed and has been available for decades. The status of its PCB application is still considered developmental, awaiting testing results and EPA approval.

Conclusions: Multiple hearth incineration can be used for sediment decontamination with a high degree of process control and high destruction percentages, but excessive costs can be expected. Because of high costs and its developmental status, PCB destruction by multiple hearth incineration will not be evaluated further.

- Critical Point Oxidation

Description: A proprietary system developed by MODAR Incorporated uses water at supercritical conditions (1300°F and 3200 psi) and oxygen to effect PCB oxidation. This process, similar to wet-air oxidation--although much more severe conditions are used--benefits from the fact that at the supercritical operating conditions, oxygen and many organic materials are completely miscible in water, greatly facilitating the oxidation process. The process has been tested using contaminated waste streams, although it was found that problems with the system develop if the waste stream is comprised of greater than 5 percent inerts.

A continuous flow reactor designed for use on harbor or estuary sediments would handle an average flow of 1,000 to 5000 gallons (4-20 tons) of solution per day. Sediments would not have to be dewatered before treatment, and all reactions would be carried out in a closed system.

Technology Status: This process is currently in the pilot plant stage of development. Early results indicate that it should be a technically and economically feasible process for many waste streams with less than 5 percent inerts.

Conclusions: Because the sediments to be treated have a solids loading of greater than 5 percent inerts, this process will not be applicable for decontamination of New Bedford harbor sediments; therefore, this technology will not be considered for further evaluation.

- **Chemical Destruction**

  - Acurex

Description: The Acurex system is a PCB dechlorination process that uses a sodium reagent in a nitrogen atmosphere to effect decomposition. After a solvent wash of the sediments, the resultant extract is fed into the reactor, yielding NaCl and polyphenyl and solvents that can later be reused. A 250 gallon per minute portable reactor has been constructed and should be available for use with contaminated soils and sediments in the near future. Large scale use of the process should follow the approval of current testing.

Technology Status: The Acurex process is a commercially available destruction process that is permitted in all EPA regions. This destruction process is however limited to the destruction of PCB contaminated liquids.

Conclusions: The Acurex process could prove to be a viable alternative to incineration; however, decontamination of the harbor sediments would first require a solvent extraction of the PCBs from the sediments. This requirement is a stumbling block to the use of this process because the EPA has not approved a PCB extraction process. Until an extraction process is approved, the Acurex destruction process will not be considered for further evaluation. Its use should be reevaluated if an extraction process is approved in the near future.

- Hydrothermal

Description: The principle of the hydrothermal PCB decomposition process, as developed by the Japanese on a laboratory scale, is the replacement of chlorine atoms of PCBs with hydroxyl groups in the presence of methanol and sodium hydroxide. Operating at a temperature of 570°F, and a pressure of 2,560 psi (pounds per square inch), this process is reportedly safe, simple, and rapid. The by-products resulting from the process include sodium chloride and dechlorinated organic compounds, which are safely burned or treated in an activated sludge process.

Technology Status: The hydrothermal destruction of PCBs is currently in the laboratory stage of development.

Conclusions: Because the hydrothermal process is only in the laboratory stage of development, and would not be available in the foreseeable future, this process was removed from further evaluation.

- APEG

Description: The APEG (Alkali Metal and Polythylene Glycol) process is a generic process by which an alkali metal is combined with a solution of polyethylene glycol and used to effect PCB destruction. There are a few processes of different origin under development which are currently awaiting additional funding and EPA approval. Two of the more technically sound processes under consideration by the EPA are:

- KOHPEG - General Electric Schnectedy, NY
- NaPEG - Franklin Research Institute, Philadelphia, PA

In the KOHPEG process, potassium hydroxide (KOH) and polyethylene glycols (PEG) react with and destroy polychlorinated biphenyls (PCBs), producing reaction products of aryl polyglycols and biphenyls. Laboratory work indicates that PCBs contained in soils with significant organic content will be destroyed, although the process may take several months at ambient temperatures and numerous applications of the reagent to complete. Decreased reaction time will be realized if elevated temperatures (150 - 250°F) are used. The process is tolerant of some water, but the use on dredged sediments will require testing to establish the limiting water content level.

The NaPEG process uses a molten sodium metal dispersed in a polyethylene glycol solution to achieve PCB destruction. NaPEG is similar in process and costs to the KOHPEG process. The reaction products of this process are oxygenated organics, sodium chloride, and polyglycol. The EPA is optimistic about its use in the decontamination of soils, but results from laboratory testing will not be available for some time.

Technology Status: Testing of both of these processes is still at the laboratory level.

Conclusions: These processes were removed from further consideration because of their technology status, and the expected high costs of implementation.

- Microwave Plasma Destruction

Description: PCBs in liquid can be destroyed rapidly and effectively by the microwave plasma process. An existing system developed by Lockheed Research Laboratory processes PCBs in liquids in a single column unit that incorporates two 2.5 kilowatt (kw) microwave radiation units to effect the destruction. The feed stream consists of the PCB contaminated liquid and a carrier gas (oxygen, oxygen-argon, or steam), and the wastes generated include CO_2, CO, H_2O, SO_2 and various waste-specific organochlorides.

This system is set up to handle approximately 20 pounds per hour of contaminated feed, but Lockheed has plans to develop a 100 pound per hour unit in the future. As yet, no testing has been done to determine the process applicability to contaminated sediments, although a solvent extraction of the sediments and treatment of the extract should be possible.

Technology Status: The microwave destruction of PCBs is still in the development stage. Only laboratory scale work has been done to date.

Conclusions: This system is not expected to be ready for use with contaminated sediments and will not be evaluated further.

- PCBX

Description: The PCBX system is a mobile process used for the destruction of PCBs found primarily in transformer oils. This system was developed by Sun Ohio, and was the first chemical PCB treatment method approved by the EPA. The system reportedly uses sodium salts of organic compounds in an amine solution to effect PCB destruction. The use of this system for contaminated sediments necessitates a solvent extraction of the PCBs from the sediment, and its qualification as a proven method cannot be made until current testing is completed.

Technology Status: The PCBX system is EPA permitted, but work with PCB-contaminated soils and sediments is very preliminary.

Conclusions: This technology is EPA permitted for use on transformer oils, but its status for use on sediments precludes its further evaluation.

- Goodyear Process

Description: The Goodyear system involves a non-mobile, exothermic process using sodium naphthaline (including naphthalene, a priority pollutant) in an inert atmosphere for the destruction of PCBs in liquids (primarily oils). Operating at ambient temperatures, the system rapidly destroys PCBs, producing sodium chloride and nonhalogenated polyphenyls as by-products. Application of this process to the sediments of New Bedford Harbor would first require a solvent extraction of these sediments, with subsequent transportation of the extract to the unit for processing.

Technology Status: This system is EPA permitted and is now standard technology for treating PCB contaminated fluids.

Conclusions: The Goodyear process was removed from further consideration because the system is not readily available (non-mobile) and would thus incur large transportation costs. In addition, the technology is not established for soil and sediment treatment.

- **Biodegradation**

Description: Biological destruction of PCBs in sediments is a process which has produced only limited success during its current development. Existing biological agents (microbes, worms) are capable of using PCBs as their sole source of carbon, but only the lesser chlorinated biphenyls (1-5 chlorines) degrade readily. The highly chlorinated biphenyls (6+ chlorines) undergo negligible degradation.

Commercial PCB Aroclors are not a single compound, but are a mixture of PCB isomers. Large scale biodegradation of PCBs is difficult to evaluate because of the varied nature of the PCB Aroclors and the uncertainties associated with the degradation of PCB isomers. No single micro-organism has been found that will oxidize all of the PCB Aroclors.

Technology Status: All work to date on the biodegradation of PCBs has been done at the laboratory level. Some organisms have been found to degrade some Aroclors, although one existing problem has not been overcome. Aroclors with 4+ chlorines have been found to be toxic to organisms that have readily degraded the lesser chlorinated biphenyls.

Conclusions: Biodegradation has been eliminated from further consideration because a feasible method has not been found for the large-scale application of the biological agent. It is possible that in the future a biological organism or group of organisms will be found that will systematically degrade all PCB Aroclors. In the case of this event, the biological process and its applicability to contaminated sediments should be reevaluated.

- **Particle Radiation**

Description: Particle radiation is often used for the destruction of wastes. Most of the work done to date has been conducted with either electron beam or gamma radiation processes. The gamma radiation technique was shown to have little effect on PCBs, while electron beam irradiation produced very good results (96% destruction) requiring less energy. There are still questions remaining with respect to the cost effectiveness of electron beam treatment.

Technology Status: Particle beam radiation treatment of PCBs in still a laboratory process. There are no reported plans to develop a sediment decontamination process.

Conclusions: Sediment decontamination using particle beam radiation is still in the early stage of development, and will therefore not be retained for further evaluation.

Disposal Actions

Disposal Within Location of Source

Description: This alternative would involve effectively cleansing the contaminated sediments by incineration. After incineration, the sediments would be disposed back into the harbor. Although incineration will destroy PCBs in the sediments, the heavy metals may cause problems in their existing state or may be altered to a more harmful state during incineration. Also, environmental effects of sediment redistribution and increased suspended sediment loads will be a principal issue. In addition, the replacement of these sediments into the harbor may cause legal and institutional ramifications. An Environmental Impact Statement and various permits may be required before this action can be implemented.

Technology Status: Not Applicable.

Conclusions: For the reasons stated above, this alternative has been eliminated from further consideration.

Disposal Outside Location of Source

- **New Upland Landfill Site**

Description: This alternative includes siting, design, construction, operation, closure, and post-closure monitoring of an upland landfill facility. The containment area would be designed as a basin with an approved impermeable liner. Contaminated materials would be deposited within the basin, dewatered or stabilized as necessary, and then covered with an approved impermeable cap, in order to minimize the generation of leachate. A collection system would be installed for the monitoring, collection and possible treatment of leachate. Groundwater monitoring wells would also be installed, in order to monitor subsurface water quality. This alternative may be difficult to implement because

- A high groundwater table is present
- Local soils are generally highly permeable
- Complex hydrogeologic conditions exist
- Some potential sites are located in environmentally sensitive areas
- Long hauling distances are associated with non-urbanized areas.

Technology Status: Landfilling is widely practiced in the management of hazardous waste sites.

Conclusions: This alternative will be retained for further evaluation.

- **Shoreline Disposal Site**

Description: This alternative assumes that contaminated sediments will be disposed in a waterfront location along the Acushnet Estuary or New Bedford Harbor. Bulkheads or earth embankments would be constructed to develop the containment site, and to isolate the contaminated materials from the estuary/harbor system. Potential disadvantages to this alternative include

- Its suitability to meet federal requirements for hazardous waste disposal
- The potential for leaching of contaminated groundwater
- The limited design life of metal bulkheads.

Technology Status:

This technology uses available engineering features, and has been previously developed as a remedial action in similar cases (e.g., Waukegan Harbor).

Conclusions: This alternative will be retained for further evaluation.

- **Existing Chemical Landfill**

Description: Several permitted chemical landfills are available in the U.S. for the disposal of PCB-contaminated sediments. These provide a straightforward resolution of the disposal problem, but unit disposal costs are high due to the transport distance and the current disposal fee structure. The closest PCB-permitted landfill is the CECOS facility near Buffalo, New York, and reportedly this site has a limited amount of space currently available for PCB-contaminated wastes.

Technology Status: Chemical landfills are permitted for the disposal of PCB-contaminated wastes, but costs are high and volume limitations may be imposed.

Conclusions: This alternative will be retained for further evaluation, particularly in regard to the disposal of highly-contaminated sediments (e.g., >500 ppm).

PCB Separation and Removal

Retrievable Sorbents

Description: Sorbents can be used to collect contaminants in natural systems because the PCBs have a greater affinity for the sorbent than the sediments. The sorbents can be incorporated with magnetic particles so that the media can later be retrieved with magnetic devices. It is expected that it will be difficult to reduce the PCB concentrations below 50 ppm in very highly contaminated areas.

Technology Status: Large-scale equipment has not yet been developed for practical application.

Conclusions: Retrievable solvents will be eliminated from further consideration, since they may not be suitable for reduction of PCB concentrations to levels below 50 ppm.

Bioharvesting

Description: This technique requires the removal of aquatic life from the harbor which have accumulated appreciable concentrations of PCBs, with subsequent disposal in an environmentally acceptable manner. An extremely large time frame would be required for this method; it has been estimated in previous studies that between 100 and 10,000 years might be required for the "clean-up" of lower levels of PCB contamination in river sediments.

Technology Status: Very little information is presently available on the implications or the feasibility of this technology. Even if test cases were developed, the large time frame involved would prohibit a timely documentation of success necessary for further consideration of this alternative.

Conclusions: Bioharvesting has been eliminated from further evaluation because it is not technically feasible.

Oil-Soaked Mats

Description: In this alternative, a medium that exhibits a great affinity for PCBs would be applied to the harbor bottom. Mats to which the medium is attached could then be retrieved to remove the contaminants from the natural system.

Technology Status: The technology is presently in a conceptual stage.

Conclusions: This technology has been eliminated from further evaluation due to its unproven technical feasibility.

Solvent Extraction

Description: This process uses a solvent, a substance for which PCBs have great affinity. When the solvent is mixed with contaminated sediments, the PCBs exhibit a greater affinity for the solvent than the sediments. The solvent will then rise to the water surface, and can be collected and removed. Problems associated with this technique include:

- The potential for toxic residues.
- The accumulation of solvent by organic sediments.
- Turbidity associated with the mixing of the sediments.
- The potential inability of solvents to reduce levels of PCB contamination in highly contaminated sediments to acceptable levels.
- Extensive costs.

Technology Status: The process is still in the laboratory stage.

Conclusions: This technology has been eliminated from consideration due to technical infeasibility.

Support Actions

Solids Dewatering

Fixation

Description: Waste fixation is a chemical process designed to seal wastes or contaminated soils in a hard stable mass, or to remove the free water in freshly dredged sediments. Agents such as Portland cement, flyash, lime, pozzolan, sodium silicate, or organic polymers are used to bind or hydrate the free water in dredge spoils. The treated material develops properties of a concrete or loose aggregate, although many of these methods are not meant to permanently secure the waste. In addition, compatibility testing must be done for each technique to determine which would be most suited for this work. A determination would also have to be made as to the point of application of the agent, as for example in-situ treatment or treatment on the shore in preparation for sediment transportation.

Technology Status: This method involves the use of some very common construction materials and common mixing technologies.

Conclusions: The fixation of sediments option was retained for further evaluation.

Mechanical/Physical Dewatering

- **Lagoon**

Description: One of the oldest and simplest methods used for solids dewatering is the sedimentation basin or lagoon. A standard design would be to use two lagoons, alternating the use back and forth as one fills up and requires emptying. Construction would be completed above grade to prevent possible contact with the groundwater. In addition, the sides and bottom of the lagoon would be sealed to prevent leakage. Sediment would be retained in the lagoon while the supernatant would be decanted and treated.

Technology Status: The construction of a dewatering lagoon uses common engineering practice and technologies.

Conclusions: Lagoon dewatering of solids will be retained for further evaluation.

- **Portable Sediment Processing System**

Description: A portable three-phase separation system was developed by the EPA to be used for contaminated dredge spoil dewatering. Sediment slurries are stored on shore in a pond awaiting initial sediment processing, which is the hydraulic separation of sand-size and larger particles using portable scalping-classifying tanks. Solids are then removed from the system by spiral classifiers (large-diameter sand screws) which collect, convey, and deposit the removed material in a discharge pile for storage before treatment or disposal. The supernatant leads to the secondary processing, which includes the removal of fine-grained materials. For this, a series of uniflow filters (hanging polypropylene hoses) would be used. Separation is aided at this stage by the addition of chemical coagulants. Final separation is achieved by a tube settler working in connection with a coagulant addition to remove particles 6 microns in diameter or smaller. Return water would then be treated and returned to the harbor.

Technology Status: The portable sediment processing system uses current engineering technologies to effect sediment dewatering.

Conclusions: This system will be retained for further evaluation during the screening process.

- **Drying Beds**

Description: Drying (gravity under drainage) bed dewatering of solids is the most widely used solids dewatering method in the United States. Low cost solids drying can be achieved in a reasonable amount of time by the use of sandbeds, requiring little operator attention and skill.

A typical unit would include at least two beds constructed with an underdrain, 8 to 18 inches of gravel or stone, and a top layer of 6 to 9 inches of sand. In addition, a major factor in the design of such a system is the local climate (the amount of precipitation, percent of sunshine, and average relative humidity). Depending upon weather conditions, upwards of 45 percent solids can be achieved by this process in as little as two weeks time.

Technology Status: This process is currently in widespread use throughout the United States.

Conclusions: Dewatering of solids using drying beds should be effective for this application and will be retained for further evaluation.

- **Dehydro Drying Beds**

Description: The sedimentation of dredge spoil solids can be accelerated by the use of dehydro drying beds. Ninety percent of the water can be removed after the addition of a flocculant to the slurry and then filtration with a permeable mat and incorporated vacuum system. To accomplish this, contaminated sediment and the associated slurry are evenly dispersed over permeable mats, and the water is drawn through the bed, aided by a vacuum. The supernatant is collected in a sump and removed or stored for eventual treatment.

Technology Status: The dehydro drying bed method of drying dredge spoils is a relatively new concept using conventional technical practices.

Conclusions: Dehydro drying beds will be retained for further consideration.

- Gravity Thickener

Description: Gravity thickeners are similar in design to conventional circular clarifiers, except that they have a greater bottom slope and are constructed with a heavier raking and pumping mechanism. Thickener operation would also be similar to the operation of a clarifier. A sediment slurry would enter the unit at the center of the thickener and solids would settle into a sump at the bottom. Solids would then be removed for eventual treatment or disposal, and the supernatant would be removed from the overflow weir system for treatment. Prior to construction for dewatering sediments, sediment loading rates should be determined in order to optimize the size and number of units required.

Technology Status: The technology for this dewatering technique is based on sludge thickening technology, and a scale up would present operational and mechanical complications.

Conclusions: Because of the need to scale-up conventional equipment, considerable testing would be required, and capital and operational costs would be prohibitive. For these reasons, this technology was not retained for further evaluation.

Secondary Solids Dewatering

Description: Secondary solids dewatering may be incorporated to improve handling characteristics and for volume and weight reduction. Methods for secondary dewatering could include:

- Vacuum Filters

These devices use a rotating drum with an internal vacuum to draw the water through the filter medium leaving the solids in a blanket in the filter cloth. For vacuum filters, the optimum solids content for filtration is about 8 to 10 percent.

- Centrifuges

A typical centrifuge is composed of a spinning cylinder, which creates high centrifugal forces that push the solids to a screen on the perimeter of the drum. The solids are retained by the screen, while the water passes through. Operation is normally continuous.

- Filter Presses

These units use high pressure to force water from the secondary solids. The most common type of filter press utilizes a series of rectangular plates, fitted with filter cloth. Carriage water is forced through the filter cloth and into collection channels. The plates are later separated and the solids removed.

- Belt Filters

These devices utilize two horizontally or vertically moving belts to squeeze the water from the secondary solids. Relatively new, belt filters have been introduced in the past few years, and are projected to perform closely to vacuum filters.

- Drying Beds

Secondary solids are placed in 8 to 12 inch thick layers on the bottom of the drying beds, and allowed to air dry. The solids can then be removed and disposed by landfill or destruction. Drying beds require large parcels of land for sizeable applications.

Technology Status: Belt filters are a relatively new technology. The other techniques are widely used for a variety of applications.

Conclusions: All of the secondary solids dewatering technologies will be retained for further evaluation.

Sediment Dispersal Control

Single Silt Curtain

Description: Silt curtains are constructed from filter fabric, and can be used to minimize the transport of contaminated sediments. Suspended from floats, the curtain is extended around the dredge site, or at least across the downstream portion of the water body. The performance of this technique is sensitive to water surface disturbances, since water may overtop or tear the silt curtain.

Technology Status: The technology has not been thoroughly tested in cases where performance is critical due to the highly contaminated nature of the sediments.

Conclusions: Single silt curtains were previously ruled out in similar applications due to perceived inadequate containment of contaminated sediments, and will be similarly ruled out in this study.

Double Silt Curtain

Description: A double silt curtain utilizes the same basic concept as the single silt curtain, except that two curtains are used in parallel with a buffer zone in between. Turbidity in the buffer zone can be further reduced by application of a cationic polymer.

Technology Status: The technology has not been thoroughly tested in similar applications, but has proven reliable in other uses.

Conclusions: The double silt curtain will be retained for further evaluation.

Sheet Piling

Description: Sheet piling, driven into the harbor sediments, can be used to limit the dispersal of contaminated sediments during dredging. An enclosure constructed of interlocking sheet piles would substantially reduce the movement of contaminated water and suspended sediment to the outside of the piling. Generally, the water level within the enclosure is maintained at a lower level than the surrounding water. Pumping and treatment of contaminated water would then be required.

Technology Status: The use of sheet piling in cofferdam construction is a common technology.

Conclusions: Sheet piling shall be retained for further evaluation.

Harbor Dewatering

Description: Dewatering of the upper New Bedford Harbor would require the implementation of several engineering technologies. A bypass pipeline or culvert would first be required in order to convey surface runoff around the upper harbor and into the estuary below the Coggeshall Street bridge. Sheet piling would then be driven into the harbor bottom across the downstream face of the upper harbor, approximately parallel to the bridge. Impounded surface waters and infiltrating groundwaters would be removed by pumping, and then piped to a water treatment system, as necessary. It is expected that extensive groundwater infiltration would occur upon dewatering of the harbor due to the high local water table and high permeability of the glacial outwash beneath the site.

Under this alternative, ambient air contamination is likely, as PCB volatilization is most extensive under exposed, saturated soil conditions similar to that of the dewatered harbor bottom. In addition, small areas of ponding on the exposed sediments may result in undesirable insect reproduction. Construction and operation costs associated with this alternative are expected to be prohibitive, as costs on the order of $10 million should be realized.

Technology Status: Although not generally applied to large bodies of water, dewatering techniques incorporate standard engineering practices.

Conclusions: On the basis of the aforementioned costs and environmental effects, this alternative has been eliminated from further consideration. Because harbor dewatering is not being considered further, any technologies that require dewatering will also be eliminated at this point. These technologies (which had previously been retained) include in-situ containment by a fabric cap or clay cap.

Surface Water Control

Sheet Piling

Description: Sheet piling can also be used in conjunction with a dewatering process to control surface water flows, and to expose contaminated sediments for subsequent removal or containment. Since the sheet piles are not watertight, water pumping and treatment would be required constantly during the excavation/construction process.

Technology Status: Surface water control through use of sheet piling is a well established method.

Conclusions: Sheet piling for use in surface water control will be retained for further evaluation.

Bypass Pipeline

Description: A gravity pipeline could be used to transport the Acushnet River outflow from the northernmost end of the estuary to a point below the Route 195 bridge. This pipeline would accommodate the dewatering of the upper estuary for sediment removal or containment purposes. However, it would still be necessary to handle the local surface water runoff and groundwater which flow directly into the upper estuary.

Technology Status: Gravity pipelines are used in standard practice. However, there are several design constraints that influence the feasibility of the pipeline for use in the estuary. One important constraint is that the available head is very small relative to the length of pipe. The maximum allowable headwater elevation is 12 feet mean sea level (MSL), which is the surface water elevation just upstream of the Saw Mill Dam during the 100-year storm. The highest tailwater condition to be considered is 6 feet MSL, which is the elevation of the harbor during a 100-year storm. This leaves an available head of only 6 feet over a distance of 11,000 feet.

Two cases were considered for design purposes: a free outlet condition and a submerged outlet condition. In the case of the free outlet condition, a 6 foot diameter pipe with a horizontal slope was chosen for the design. This would be the largest pipe that could be used in this case, since the available head is only 6 feet. For the design flow of 1350 cfs, seven pipes of this size are required. This design then is infeasible due to the limited space under the two concrete arch bridges just downstream of the Saw Mill Dam.

If the outlet is submerged, larger pipe sizes may be used, and 10 foot diameter pipes were chosen for design. For this condition, four 10-foot pipes are required to carry the design flow. Again, the case is also infeasible due to the physical limitations imposed by the aforementioned bridges..

Conclusions: It has been determined that use of a pipeline to convey the Acushnet River flow through the New Bedford Harbor is technically infeasible due to limited area under the bridges to accommodate the pipes and will not be evaluated further.

Bypass Channel

Description: A bypass channel would be constructed to carry the Acushnet River flows across the upper estuary to the Coggeshall Road bridge. The channel could be constructed from sheet piling, earth berms, or as a structurally supported aqueduct. Construction of the channel would permit dewatering, treatment, or dredging of the upper estuary, independent of tidal effects and without disturbance/contamination of river flows.

Technology Status: Channel construction is a straightforward and commonly used practice.

Conclusions: This technology shall be retained for further evaluation.

Water Treatment

If the removal of PCB contaminated sediments from the upper New Bedford Harbor is chosen as part of the remedial action, an estimated 1,000,000 cubic yards of contaminated sediments will be removed from the harbor. These sediments will require treatment or landfilling, depending upon which solution proves to be cost-effective.

Coagulation/Sedimentation/Filtration

Description: Coagulation, sedimentation, and filtration have been commonly utilized to collect and remove normally non-settleable particles from contaminated water. Initially, a coagulant is introduced and mixed with water. Physical and chemical transformations result in the formation of floc. The water is then flocculated (gently agitated) to expedite the growth of floc particles. During sedimentation, the flow-velocity is reduced to allow settleable floc particles to be removed from suspension. Finally, filtration is used to remove all remaining solids that were not settleable during the sedimentation phase. Three filter medias to consider are:

- Granular, activated carbon
- Klensorb and granular activated carbon
- Mixed media

Mixed Media Filtration

PCBs are generally insoluble in water and they have a high affinity for organic sediments, and so the removal of these sediments from the treatment stream will in turn remove a high percentage of the PCB contamination. Mixed media filtration is an inexpensive filtering system that can effectively remove suspended solids from waste water streams. For such a system, fine grained sand and anthracite are used in sequential layers to effect the filtration of the PCB contaminated waste stream.

This type of filter media will, in general, selectively remove the insoluble fraction of the PCBs that are adsorbed to the suspended sediments. The PCBs that are dissolved in solution or have formed an emulsion are not removed by this type of filtration. A high PCB removal percentage can be expected, however, due to the largely insoluble nature of PCBs. Treatability testing will be required to determine if this type of filtration will produce an effluent that can be discharged into the harbor.

Carbon adsorption has been the most widely used process for the removal of PCBs from industrial wastewater. It has proven to be particularly successful in the removal of soluble PCB fractions to below detectable limits in the process effluent. Carbon particles have an extensive surface area that is particularly suitable for the collection of soluble substances. One obstacle to the use of carbon adsorption is that the surface of the carbon is also susceptible to clogging and blinding by suspended solids. Accordingly, a prerequisite to carbon treatment would be influent sedimentation and filtration.

Klensorb (trademark) is similar to activated carbon and finds its best application when used in combination with carbon. Because Klensorb is not adversely affected by blinding of the absorbent particles, as is carbon, the life of a tandem treatment system can be much greater than a granular activated carbon (GAC) treatment system alone. (PCBs are oily and can be particularly troublesome to blinding of the carbon surface). Some testing has been done with this system, and it has proven to be very effective in the removal of PCBs in water.

Technology Status: Coagulation, sedimentation and filtration processes are commonly used in wastewater treatment. Carbon adsorption of PCBs is a proven technology, and the technology for the use of Klensorb in combination with GAC is presently commercially available.

Conclusions: This alternative will be retained for further evaluation.

UV/Ozonolysis

Description: PCB destruction in wastewater can be achieved with very good results when the water is treated by the use of ultraviolet (UV) light and ozone. This method is suited to treatment of large quantities of waste, although some stringent process conditions must be met. The effectiveness of UV irradiation decreases rapidly with increasing depth, so only a thin film of the process stream can be treated at one time, creating the need for a large surface area. In addition, ozone will decompose at high temperatures so excess heat must continuously be removed from the system.

One problem to be overcome is that ozone is a non-selective oxidant, and it is not known if undesirable end products would develop. Treatability studies would have to be performed on the harbor sediments to determine if further treatment would be required.

Technology Status: The technique of using ultraviolet light and ozone to destroy PCBs in wastewater is currently in the pilot plant stage of development.

Conclusions: Since this technology is still in the pilot plant stage of development, and is not available for large-scale use at this time, the system will not be further evaluated.

Catalytic Reduction

Description: Catalytic reduction of PCBs results in the reduction of the chlorine groups on PCBs, leaving a hydrocarbon skeleton that would be susceptible to further biochemical (or other) oxidation. There are no data on the actual performance of the process, which uses a copper-iron catalyst to effect PCB reduction.

Technology Status: The reduction of PCBs using a copper-iron catalyst is in the conceptual stage of development.

Conclusions: Because of its developmental status, this treatment technology will not be further evaluated.

Wet-Air Oxidation

Description: Wet-air oxidation involves an aqueous phase rapid oxidation of dissolved or suspended organic substances (PCBs) at elevated temperatures and pressures. An almost complete destruction of PCBs can be achieved by a system using a co-catalyst at moderate temperatures (530°F). One method uses a bromide and nitrate anion catalyst in an acidic aqueous solution to accomplish PCB destruction in excess of 99 percent. The primary advantage of this system is that no dewatering is necessary. This process is also energy efficient because it is exothermic, and steam can be obtained from the unit and reused in the process.

Technology Status: Wet-air oxidation treatment relies on technologies that were originally developed in the 1950s, and has been successfully applied to PCB-contaminated wastewaters.

Conclusions: Although the technology is available to achieve the treatment objectives, there are no commercial systems available for PCB destruction, and there are no plans for their development. This technology was removed from further consideration since it is presently not available, and has high costs associated with the development and testing of a commercial unit.

High-Efficiency Boilers

Description: Wastewater containing up to 500 ppm of PCBs can be decontaminated using high-efficiency boilers. A typical system would inject PCB-contaminated water along with a fuel source into a boiler-tube lined incinerator, where destruction occurs at approximately 200°F. Much of the heat generated during the process can be recovered as steam generated in the boiler tubes. This steam can then be reused in the process or for power generation.

The high-efficiency boiler destruction of PCBs in water is a very efficient process, whereby PCB contaminant levels can be reduced to almost non-detectable limits.

Technology Status: The technological basis for this process is acceptable, but the process has not been widely used in industry because of high initial capital costs.

Conclusions: Because of the high development and implementation costs that would be associated with the construction of a high efficiency commercial boiler, this process will not be evaluated further.

Chlorinolysis

Description: Chlorinolysis would involve the conversion of PCBs to carbon tetrachloride by the addition of chlorine under high pressure and temperature conditions. This process is not reaction-specific, so undesirable by-products may result. This process has not been tested for its applicability to PCB-contaminated water.

Technology Status: Although this process has been proven to be successful in converting many chlorinated hydrocarbons, no work has been done with PCBs.

Conclusions: Chlorinolysis will not be retained for further evaluation because its applicability to PCB-contaminated wastes is unknown.

Goodyear Process

Description: The Goodyear system involves a non-mobile, exothermic process using sodium naphthalide in an inert atmosphere for the destruction of PCBs in liquids. The reagent rapidly destroys PCBs at ambient temperatures, producing sodium chloride and nonhalogenated polyphenyls as by-products. Treatment volumes could be reduced by using a solvent extraction of the liquids. The Goodyear process includes the use of a priority pollutant (naphthalene).

Technology Status: This method is EPA-permitted and uses available technology.

Conclusions: Since this system is non-mobile (no mobile unit has been developed), a further evaluation of this technology has been declined due to logistical problems.

PCBX

Description: The PCBX system is a mobile process used for the destruction of PCBs found primarily in transformer oils. This system reportedly uses sodium salts of organic compounds in an amine solution to effect PCB destruction. Water treatment will occur after solvent extraction, although this may not be a cost-effective solution.

Technology Status: This process is EPA-permitted, and uses available technology for treatment of PCBs.

Conclusions: Although this process has proven useful for treating PCBs in oil, no recommendations have been made as to its use on PCBs in aqueous streams, thus eliminating this technology from further evaluation.

APPENDIX C

SECONDARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES

C.1 Hydraulic Control

C.1.1 Technical Feasibility

The following two techniques, an earthern channel and a sheet pile channel, were evaluated as means of hydraulic control in the upper harbor. Available engineering data on the depth and physical properties of the silt along the harbor shoreline indicate that the construction of the earthen channel is technically feasible.

Sheet piling has been successfully used in other projects performed in the harbor area, thus also verifying the technical feasibility of this method. However, local harbor bottom characteristics may limit the construction of the sheet pile channel. These factors are discussed under implementation factors.

C.1.2 Potential Impacts

After the construction of either type of channel, the potential for contamination of the Acushnet River flows is minimal. This risk will be minimized by using an impermeable synthetic membrane in the construction of the embankments. Other construction materials include rock fill and well graded glacial till. The membrane will be placed between the rock fill and the glacial till core, with the membrane and the glacial till aiding in keeping the contaminated sediments from reaching the clean waters in the channel.

Proper construction of the sheet pile channel is also the key in preventing contamination of the clean water. If tight interlocks are achieved between sheets, the potential for contamination is minimal.

C.1.3 Implementation Factors

A possible problem with the channel design is the placement of the sand foundation. The foundation is to be formed by placing the sand directly on the existing harbor bottom, thereby displacing nonload bearing sediments and providing a stable base for the embankment with the sand. The amount of sand required for this operation cannot be determined at this time.

Several problems are also associated with the construction of the sheet pile channel. Typical pile driving equipment and techniques may not be suitable for the proposed construction. It is expected that sheet piling will be driven into the harbor bottom where the water is generally between 1 and 4 feet deep. Since a typical barge-mounted rig may require drafts in excess of this depth, special means of flotation may be required for proper mobility. Another solution may be to increase the water depth by dredging in the work area. Two other factors which may complicate construction are the presence of storm sewer outfalls along the west shore and existing utilities on the harbor bottom. Any boulders or other debris present in the underlying glacial till may also pose problems if encountered while driving the pilings. Also, the following assumptions were made regarding the construction of the sheet pile channel:

- The maximum hydrostatic head differential acting on the sheet pile wall is 8 feet.
- No backfill will be placed against the piling.
- The top of bedrock is at or below -40 feet MSL.

Variations in these assumptions could greatly affect the implementation of this option.

The time required for construction of both the sheet pile channel and the earthen channel will require slightly less than one year. While no maintenance of properly installed sheet piling should be necessary, it is recommended that an inspection program be implemented. Occasional removal of debris and silt from the channel may be necessary. The earthen channel will also require periodic inspection and cleaning. A comparison of the costs of these channels revealed the cost of the sheet pile channel will be at least three times that of the earthen channel. The costs were estimated based on the construction of two parallel structures, sheet pile walls or earthen embankments, extending from the Wood Street Bridge to the Coggeshall Street Bridge. Both options would require some legal or institutional requirements or regulations necessary for implementation.

C.2 Solids Dewatering

In this section, five technologies are evaluated for the primary dewatering of the sediments. These technologies are evaluated based on technical feasibility, implementation factors (such as drying rates, time required to achieve resultant percent solids, cost, etc.), and potential impacts of the technology. The five technologies assessed include dewatering by solidification/fixation to entrain the liquids, and dewatering via gravity or physical/mechanical means. The latter category includes lagoon dewatering, drying beds (without vacuum assist), dehydrodrying beds (with vacuum assist), and a portable dewatering system.

C.2.1 Technical Feasibility

When evaluating a fixation or solidification technology, the contaminants present in the waste stream must be considered so that materials that are compatible with the contaminants will be used for the process. While the fixation/solidification of metals is a recognized technique, the process is not as well-developed for wastes containing organic material, especially those with an organic content greater than 5 percent. The presence of PCBs in the sediments further complicates the process, since no method is known to physically or chemically "fix" PCBs in the cementitious matrix without a risk of long-term leaching. The subsequent analysis will assume, therefore, that the sediments will have to be handled and disposed as a hazardous waste, even if they are solidified through a fixation technique.

The solidification technique being considered utilizes flyash and lime as the solidifying agents. This process was chosen because the flyash is a waste product of coal-fired power plants and therefore does not require a material purchase cost.

Solidification will take place by pumping the solids stream (sediments) and mixing it with enough flyash to yield a 50% solids slurry. Also added to this stream is lime at 3% by weight of the above sediment flyash slurry. This mixture is fed through a mixer, and the resultant product is placed onto an inclined conveyor belt. The material is conveyed to a lined disposal area and dropped into manageable piles so that it can dry and be spread with a front-end loader, then compacted in place.

In designing a system to handle 1,000,000 cy of dredged sediments, many logistics problems must be solved. Assuming a source of flyash is available to meet the need, it must be determined whether the material can be brought in at the rate required to keep pace with the dredging. This presents a serious limitation on this technology since no local (or possibly regional) sources are available for the estimated 2,000,000 tons of flyash required. When the supplying of lime is also considered, it becomes evident that even the traffic flow of materials will present a serious impact on the local area. This process must run continuously to maintain a manageable flow rate and to keep up with the dredging rate. A series of storage silos will be needed for the lime and flyash so that one silo for each material can be used for the feedstream while the others are being filled.

Since it is assumed that dredging will not be done 24 hours per day, and solidification will be a continuous operation, short-term storage of dredged materials will be needed. Sediment storage will also be necessary to prevent shut-down of the solidification process should dredging be interrupted for any reason.

As a remedial action technology, lagoons would provide a limited degree of dewatering of dredged material by allowing the settling out of suspended sediment particles. Lagoon dewatering will consolidate the volume of sediments that will be permanently stored, transferred to a disposal site, or treated (e.g., by incineration).

The lagoon may be of a self-dewatering type wherein any standing liquids are continuously removed via weirs and/or an underdrainage system. Since high concentrations of particles are expected for the lagoon influent, "hindered" settling will occur, resulting in an agglomeration of particles settling as a blanket on the bottom of the lagoon. Further settling of the particles results in compression of the sediments.

Once sedimentation has progressed to a predetermined point, the aqueous supernatant must be drawn off and treated. Because of the nature of contamination in the sediments, the bottom and sides of the lagoon should be lined with clay and/or a synthetic liner to prevent leakage and ultimate hydraulic connection with the groundwater.

Drying beds are similar to lagoons, but differ in that they incorporate a subsurface drainage system consisting of three components: the filter material, the conduit, and the disposal system. Downward flow of water through the dredged material is primarily a result of gravitational forces. The collected water is removed from the system, allowing additional dewatering to occur. A continuous flow condition is usually not maintained in the underdrainage layer. Water essentially drips from the dredged material, and the static water level in the underdrainage layer is at the flow line of the collector pipes.

The filter material must be fine enough to prevent infiltration of the soil grains into the drains, and coarse and pervious enough to allow the flow of water into the drain. General criteria for selection of proper underdrainage material are that it be free-draining and free of fines (5 percent or less passing the U.S. #200 sieve). Laboratory tests confirmed by field testing showed that either standard well-graded concrete sand or fine uniform sand worked satisfactorily, as did filter fabric with openings equivalent to U.S. #70 to #100 sieve size placed over any porous and free-drainage layer (pea gravel, crushed stone, mussel shell). Where sand layers are provided as underdrainage material without the use of collector pipes, it has been found that the sand will normally develop such large pore pressures as to render the material ineffective as a drainage layer. Laboratory testing is recommended prior to selection of an actual site-specific filter design.

Subsurface drains are embedded in a backfill of filter material laid on the bottom of a trench to collect and dispose of water that drains through the sediment.

Conduits may be pipe made of metal, clay, or plastic, or may be open-jointed tiles. The conduits channel the water to the disposal system by gravity or by pumping.

The underdrainage system must be installed prior to sediment disposal. Once disposal is initiated, the drainage layer will begin to function by carrying off the free water, as well as accelerating self-weight consolidation in the material deposited over the drainage layer.

It is desirable to analyze actual conditions at a disposal area since these may govern selection of an appropriate design. Properly designed drying beds are technically feasible but this is a time-consuming effort that requires experience and judgement, in addition to test borings and laboratory analysis.

Dehydro testing beds are similar to normal drying beds with the addition of a partial vacuum maintained in the underdrainage normal layer. For this technique, a membrane is placed between the dredged material and the drainage layer so that a partial vacuum can be maintained by a practicable amount of pumping. Partial vacuums of 15-20 inches of mercury (or about 7 psi) have been obtained and maintained. Because of the magnitude of dredged material containment area required for New Bedford, the volume of water would probably be relatively small compared to other dewatering techniques. Partial vacuum assist might be practicable where otherwise considered too costly. Systems could be designed so that dewatering pumps can operate within predetermined negative pressure limits. In addition, soils with an effective average grain size less than about 0.05mm are more rapidly drained by vacuum methods than with other methods.

For this project, vacuum systems may not be technically feasible. In addition to the unavailability of processing equipment of this large size required, the placement of drying beds on unconsolidated sediments may not be possible due to the weight associated with these bed sizes.

The portable dewatering system which was evaluated consists of two elevated clarifier bins, a bank of hydrocyclones, a cartridge filter unit, and a uni-flow bag-type filtering system. This system is primarily a separation system whereby solids are removed from the slurry at each stage of the process, with only a small amount of thickening.

Solids separation processes by design remove sediment particles of a certain size from a slurry but do not typically dewater sediment streams. The process under consideration has passed the initial screening process because the system is effective in the removal of solids from sediment slurries, although after additional investigation of this process, it was determined that solid streams removed from the process stream were not significantly dewatered and would still require secondary solids dewatering.

C.2.2 Implementation Factors

It has been estimated that it will require a lagoon having a 10-ft. depth and requiring approximately 65 acres for the dewatering of 1×10^6 cy of sediments, assuming the lagoon is to contain the entire volume of material at one time. It is unlikely that this area of shoreline or upland tracts of land will be available for dewatering nearby, since the surrounding land is used primarily for residential, industrial, and agricultural purposes. If the dredging rate is decreased to match the dewatering rate, or if it is not required to dewater the entire volume of sediments at a single time, it may be possible to use the cove on the western shoreline of the upper harbor for a dewatering lagoon.

The use of a drying bed will also require a large land area and the use of vacuum is not expected to decrease this requirement significantly. The sediments will dewater more rapidly if they are placed in thinner lifts; however, this results in a lesser volume of material being dewatered per unit time. If the required dewatering area is large or of irregular topography, dewatering may be accomplished in cells created by constructing inner dikes within the total lagoon area. For the portable dewatering system, the desired effluent has not been achieved in pilot scale tests; the sediments would therefore require storage in a lagoon, and separated solids would require further dewatering.

The solidification process has the disadvantage of increasing the volume of materials to be disposed by the addition of flyash and lime.

The land required during this operation must also contain the storage silos for the lime and flyash, a dredge spoils holding tank, the mixing equipment, and the conveyor system. In addition, there must be sufficient area for vehicle access and turnaround, a drying area, and a disposal site. Assuming a disposal depth of 20 feet, over 200 acres of area will be required if the fixation process is to be used prior to disposal.

With the addition of flyash and lime to the dredged materials, the resultant material extruded from the mixer is in a semi-solid form. After being discharged from the conveyor belt and placed in piles, the material is expected to 'set-up" in a few hours to a few days. While drying, the material in this form can be excavated and placed in its final disposal site where further drying and compacting may take place. If operated 24 hours per day to keep up with an in-situ dredging rate of 400 cy/hr at 10 hours per day, this process should take approximately one year to complete.

The settling rates for lagoon dewatering vary with particle size. It is expected that sand and gravel material will dewater in a matter of 1-2 days. However, the exact rate at which drying/dewatering will occur with fine-grained sediments on a site-specific basis is unknown. Predictive methods and equations that require this information for feasibility studies exist and may be used for final design. It is recommended that sediment testing be performed to determine the exact types of clays present in the material to aid in this analysis.

Underdrainage begins to function and self-weight consolidation accelerates as soon as sediments are deposited.

Field data have shown that a pressure of negative 8 psi will cause an increase of about 50 percent over non-vacuum assist techniques in the dewatering rate and a 30 percent increase in the seepage consolidation dewatering rate. Fine-grained sediments will eventually consolidate from the decant point to a water content near the liquid limit without underdrainage, but it is important to remove the ponded water which occurs on the surface of the sediments underdrainage should allow the sediments to achieve the dewatered state much more readily. Drying rates also depend upon sediment particle size, climatic conditions, degree of consolidation required or desired, lift thickness and initial water content. Rates therefore can fluctuate greatly. Sediment dewatering will be severely reduced or curtailed during the winter months when freezing prevents dewatering.

After the material is dried to a more stable form by sedimentation and evaporation, its thickness will depend upon its engineering properties, particularly its plasticity. Sediments with a high plasticity index will hold a higher amount of water and will take a longer time to dewater. A fine-grained material (with a high plasticity index) will require an extended period for dewatering to a point at which its water content will approximate its liquid limit.

The portable dewatering system was designed to handle sediment slurries of approximately 17 percent solids, with the ability to process approximately 500 gallons of slurry per minute.

Underflow streams of this process average less than 25 percent solids. This will make it necessary to include additional dewatering steps to reach the desired sediment dryness (roughly 50% solid by weight) required for treatment or disposal. Additional
processing will result in an increase of capital expenditures to achieve the desired effluent.

The solidification process will result in a percent solids content of over 50% by volume; however, this is not without a substantial increase in the volume required for disposal of the material.

Lagoon dewatering may net a solids content of 25 to 30% in a time period comparable to that for drying beds, but without the additional costs.

Construction costs for lagoons range from $80,000 to $90,000 per acre of containment area. Operational and maintenance costs are relatively low. The cost of the land area required for construction will depend on local real estate values, but generally run about $10,000 per acre (although this cost would be significantly lower if the cove is used), and are additional as initial capital outlay costs. Operation and maintenance costs for lagoons may include the equipment and labor necessary for

- Removing ponded supernatant and transporting it for treatment

- Secondary dredging of the lagoon to provide additional storage/dewatering area

- Maintaining the physical integrity of the lagoon(s) itself

- Placing additional dredge material for dewatering

Construction, operation, and maintenance costs must reflect many variables in a particular design. Some of the major considerations include

- Land area acquisition.
- Transport distance from dredge site to containment area.
- Equipment Rental
- On-site treatment of wastewater, if required.
- Suitability of proposed containment area geology.

Construction costs for a lined area would be in the same range as that for lagoons. Operational and maintenance costs associated with this alternative are relatively low and are considered a distinct advantage. Most of the operational considerations involving long-term site management will result in increased capital construction costs. Usually, however, the unit costs of operation will be equal to or lower than costs for an unplanned operation. For dehydro drying beds, maintenance costs are slightly increased, over gravity drying beds, due to the operation of the vacuum pumps.

The solidification process would incur costs for pipe and pumps to bring in the dredge spoils, storage basin(s) for dredge spoils, storage silos for lime and flyash, a pugmill for mixing, conveyor belt(s), front end loader(s), compactor(s), labor, material costs, and rail and trucking costs for bringing in the materials.

The capital cost of the solidification plant has been estimated to be $6.5 million, and the 2-year operating cost of the plant has been estimated to be $54 million for the processing of 1300 gpm of slurry.

The water present in the material dredged from the harbor will become a part of the resultant matrix during the solidification process; thus, the water to be treated will result mainly from water infiltration into the disposal area. For the other dewatering techniques, the water produced as a result of these processes, will be collected and pumped to a water treatment facility to be built on site or nearby the disposal area.

C.2.3 Potential Impacts

All of the dewatering techniques being discussed will have some impact on the community, public health, and/or the environment. The solidification process will require a large parcel of land for the processing equipment, although upon completion of treatment, the plant may be disassembled and the land returned to its prior use. Because of the large quantities of flyash (approximately 2 million tons) and lime (over 200,000 tons) to be hauled in, there will be large traffic problems incurred in the area. The process will operate 24 hours per day to keep up with the daily dredging rate and to keep the process flow rates at manageable levels, resulting in significant noise problems in the area during this operation. At the completion of the process, as much as 9 million cubic yards of material may be produced, requiring over 200 acres of land for disposal. It is suggested that testing on sediment samples be performed to determine the optimum solidification materials to be used for the process. Additives may be needed if the land used for disposal will be utilized for purposes requiring more structural support.

For dewatering lagoons and the drying beds, similar impacts on the community, public health, and the environment will be incurred. The possibility of groundwater contamination is of concern due to the shallow groundwater table indicative of the area and the length of time necessary for the dewatering process.

Subsurface transport of PCB is critical because of the potential of drinking well contamination. The contaminant concentration possible with the water-bearing zones is dependent upon site-specific conditions, including the characteristics of the PCB. Because of the persistence and high bioaccumulative properties of PCBs, strict design and monitoring of the dewatering procedure is imperative.

Covering contaminated material with clean soil is a potential management practice that can be applied to this alternative once dewatering is complete. Where contaminated material is to be used for land reclamation, covering with clean material can be an effective method for isolating contaminants from biological populations about the site. The depth of cover material should be sufficient to isolate contaminants from plant roots and burrowing animals.

Containment areas that have been filled have potential use as recreational sites. Recreational use of containment areas is popular because it requires minimum planning and lower cost as compared to commercial uses. The nature of recreational sites with much open space and light construction is especially suited to the weak foundation conditions associated with fine-grained dredged materials.

C.3 Sediment Dispersal Control

The comparison of sheet piling and a double silt curtain is presented below.

C.3.1 Technical Feasibility

Both sheet piling and the double silt curtain are commonly used technologies. There are many suppliers, manufacturers, and installation service companies throughout the country making materials for both technologies readily available. Table C-1 shows silt curtain specifications, based on field studies conducted by the U.S. Army of Corps of Engineers in 1976. As shown, the specifications for use of silt curtains is fairly standard, but can be adapted for use in the harbor as noted with tear strength and tension members applicable for currents.

C.3.2 Sediment Control Efficiency

Since sheet piling is used primarily for flow containment, as a sediment dispersal control structure, it presents a variety of problems. If the sheets are placed such that flow is reduced to allow suspended sediment to fall out, water ponding is also likely. If the piling is installed so as to allow for water flow, then sediment escape is very likely. In addition, flood conditions combined with subsequent flow restriction would apply high hydrostatic forces to the piling. This could result in risk of piling collapse and subsequently high sediment loss.

Fabrics, however, have been developed that will control sediment dispersal of varying particle size. Typical dredged sediments fall into the 0.5 mm and smaller particle size range (85% finer than 0.5 mm, Mallory and Nawrock; 1974). Fabrics will also support extremely high loads of sediment without ponding of the water.

TABLE C-1

RECOMMENDED SILT CURTAIN SPECIFICATIONS

Parameter	Recommended Value
1. Skirt Depth	10-ft. maximum allowing 1-2 ft. clearance between skirt & bottom.
2. Fabric	$\geq$300 lb/in.
a. Tensile strength	
b. Tear strength	
18 oz.	$\geq$100 lb - quiescent conditions.
22 oz.	$\geq$200 lb - medium to high current
c. Abrasion resistance	$\geq$200 lb/in. tensile strength after abrasion.
d. Material	Nylon
e. Coating	PVC
f. Weight	18 - 22 oz. (depending on material used)
g. Seams	Heat sealed.
3. Buoyancy	
a. Ratio	>5
b. Type	Solid, closed cell, and enclosed in a fabric pocket.
4. Connector	Load transfer type - aluminum extrusive or equivalent.
5. Ballast	
a. Type	Noncorrosive
b. Weight	See Figures 16 and 17.
6. Tension Member	
No current.	Fabric only.
Current (0.1 - 1,0 knots)	Top or center tension; center tension provides slightly greater effective skirt depth.

PCB's possess the characteristic of low-solubility in water and are more commonly associated with oils and fine sediment particles. Also, it has been shown that during hydraulic dredging operations, a highly contaminated scum develops on the water surface. Silt curtains are effective in retaining this scum for removal and treatment during dredging.

Under quiescent conditions, turbidity levels outside a curtain that is properly deployed and maintained may be reduced 80-90 percent of the levels inside. With a double silt fence, greater reduction of sediment and turbidity can be anticipated. Curtain deployment configurations are critical to performance. The curtain length also must be such that the skirt does not lie on the bottom during any part of the tidal cycle.

Studies show that sand and coarse silt fractions settle out quickly and clay takes the longest time. While some of this material settles out inside the curtain due to flocculation, the remaining fine material is carried under the curtain by the current flow.

The most common failure results when suspended material from the dredging operation builds up until it reaches the skirt bottom. This requires the removal of sediment build up most likely by the same methods as those being employed upstream. Another failure is parting of the seam between joined segments, allowing leakage.

C.3.3 Implementation Factors

The time required for implementation of a double silt curtain is rather quick, in the range of three or four weeks. The installation of a sheet piling control barrier is estimated to take six weeks, disregarding pre-construction site investigation time. As part of the pre-construction activities, an exploratory subsurface investigation is conducted to provide information regarding the site and soil strata. More detailed data (such as soil strength and properties and bedrock location) is also needed. Various components of the actual installation must first be engineered and designed.

Once this preparatory work is completed, the actual placement of the sheet piling may commence. Actual installation time depends on several variables. Single wall sheet piling is most applicable for shallow water flows (5-10 feet). Piling can be driven by hand with light equipment or, where soil and flow conditions warrant, with drop hammer/steam driven equipment. Large bodies of water and difficult equipment access situations would require a barge to move the equipment. The length of sheet piling required depends on stream depth, flow velocity and stream bed soils. In general, the ratio of exposed piling to driven length is about 1 to 1.

Maintenance of the silt curtain would require periodic inspections of the fabric installation for excessive wear and puncture. Periodic examinations would also be required for the sheet wall, particularly of the surrounding soil conditions. This inspection is necessary to evaluate the stability of the structure. Hydrostatic and wave pressures may exert lateral forces on the piles causing them to move. Repair or replacement of affected silt curtain panels, flotation or mooring buoys, connectors, etc. can be performed with minimal downtime. Specialized training or skills are not required for this type of maintenance. However, repair or repositioning of sheet piles would most likely cause considerable downtime for the dredging operations. Equipment and experienced labor would be required for these repairs.

C.4 Dredging Equipment and Techniques

C.4.1 Introduction

Several principal types of dredges have been designated for further consideration for removal of contaminated sediments from the upper Acushnet River Estuary. These include the clamshell (bucket), hopper, hydraulic pipeline types (dustpan, plain suction, and cutterhead), and pneumatic (air lift) dredges.

However, there are basically only three mechanisms by which dredging is actually accomplished:

- Mechanical Dredging: Removal of hard or loose material by clamshell, dipper, or ladder dredges, either for maintenance of navigation channels, or for new work projects.

- Suction Dredging: Removal of loose materials by dust pans, hoppers, hydraulic pipeline plain suction, usually for maintenance dredging projects.

- A Combination of Mechanical and Suction Dredging: Removal of loose or hard, compacted materials, either for maintenance or new work projects.

The following factors are considered in the procedure of selecting dredging equipment and the method used to perform the dredging:

- Physical characteristics and quantities of the material to be dredged
- Production required
- Method of disposal and distance to disposal area
- Dredging depth
- Physical environment of (and between) the dredging and disposal areas.
- Contamination level of sediments
- Type of dredges available.

Advances in dredging have been made in recent years. Advanced dredging technologies are directed toward one or more of the following areas of improvement: decreased environmental harm; higher production efficiency; greater precision, accuracy, and control over the dredging process; and greater depth capability. Brief descriptions of some of the major recent innovations in production dredging are listed below:

- Improved designs of dredging heads to minimize material resuspension.

- Use of silt curtains during dredging and open-water disposal to restrict turbidity plumes and, in the case of contaminated materials, limit the added dispersion due to dredging.

- Closed-bucket modifications to reduce loss of fines and liquid from bucket dredges.

- Ladder-mounted submerged pumps for higher production.

- Improved production instrumentation to monitor flow rates, densities, cumulative production, etc.

- Improved navigation, positioning, and bottom profiling instrumentation. The state of the art includes advanced laser, electronic, and acoustical systems.

- Depth and swing indicators for mechnical dredges.

C.4.2 Cutterhead Dredges

General Description of Dredge and of Operation

A cutterhead dredge combines both mechanical and suction dredging. Three types of cutterheads are available: (1) rotary, (2) bucket wheel, and (3) horizontal auger-cutter. The horizontal auger-cutter is generally known by the trade name "mud cat" or other trade name, depending on the manufacturer. The horizontal type will be discussed in Section C.4.3. The traditional cutterhead dredge is equipped with a rotating cutter mechanism which surrounds the intake end of the suction pipe. This dredge can efficiently dig and pump all types of alluvial materials and compacted deposits, such as clay and hardpan. The larger and more powerful machines are able to dredge rock-like formations such as coral and the softer types of basalt and limestone.

The bucket wheel is a rotating wheel excavator consisting of bottomless buckets and a stationary receiving hopper mounted inside the rotating wheel. The excavating wheel is driven by slow speed, high torque, hydraulic motors through a gear box. Options include standard and high volume bucket systems. The standard configuration is utilized in normal hard digging service, while the high volume system maximizes production in moderate to soft materials. Provision is also available to recirculate the dredge water to the contained hopper within the cutterhead. This would minimize the treatment of water from contaminated dredge materials. Usually, the bucket wheel module is designed to be interchangeable with a conventional rotary cutter excavating module mounted at the forward end of the dredging ladder.

The bucket wheel has a high excavating force at the cutting edge, operates with equal efficiency in either direction of swing, and achieves a greater positive feed by passing excavated material through the buckets to the suction pipe, maximizing the percent of solids to the discharge pump. The positive feed feature allows control over the percent solids passing into the pump by controlling the wheel rotating speed and/or dredge swing speed to suit the solids-water ratio required. Additional features of the bucket wheel include:

- The "digging angle" at the face to be dredged remains constant regardless of the angle of inclination of the ladder.

- The hopper design improves excavating capabilities at depths less than one wheel diameter. This design allows air to escape before entering the suction line.

- Primary separation of unwanted size or trash may be accomplished through the use of optional classification plates installed on the excavating wheels.

In cutterhead dredging, the pipeline transport distances range up to 3 miles. For upland fill operations transport distances can be as far as 15 miles for which the use of multiple booster pumps is necessary. The dredge size ranges from 8 to 36 inches in diameter. However, a 6-inch size may be provided for low productin requirements. Production rates vary according to the material being dredged, dredging depth, horsepower of dredge pumps, pumping distance to disposal area, and often operational factors that are not necessarily consistent between dredges of the same size. There is a wide range of production for dredges of the same size.

The cutterhead dredges are not self-propelled and an auxiliary power vessel may be required for manuvering. Mobility during operation is by use of stern spuds jointly operated with anchors and swing cables at the bow which are manipulated by winches. The cutterhead dredges are portable as one piece or require take down to 3 or less major pieces as required by model size. Cutterhead dredges are illustrated in Figures C-3 and C-4, presented later in this section.

General Characteristics

Dimensions: Many sizes and variations of cutterhead dredges are available from several manufacturers in the United States. Typical dimensions and related information are tabulated for various sizes (pipeline diameter) as follows:

Pipeline Diameter in.	Weight tons	Length ft.	Width ft.	Draft in.	Maximum Depth of Single pass Excavation in.	Production Rate cu yd/hr
8	18.5	44	11	35	18	45-105
10	72.5	90	17	43	18	60-300
12	73.5	90	20	42	18	120-540
14-16	87-166	95-130	20-28	43-55	21	160-875
20-24	320	180	32	56	24-30	310-1615
30	350	225	36	60	36	575-2500

Mobilization/Demobilization: Cutterhead dredges are of singular or modular construction and require transport and assembly equipment.

Special Equipment: Cutterhead dredges are generally self contained and require very little special or extra equipment. Each manufacturer provides variations to make equipment versatile and adaptable to particular project needs. The hydraulic pipeline, which is a basic part of the dredge, transports dredged material long distances directly to containment structures or other disposal areas. Transport to upland disposal areas would require additional pipe and booster pumps or transport by other means such as truck haulage.

Equipment Availability: The hydraulic pipeline cutterhead suction dredge performs the major portion of the dredging in the United States. It is manufactured by several firms in the United States and is available by purchase or by lease.

Technical Feasibility: The hydraulic pipeline cutterhead suction dredge is the most commonly used dredging vessel and is generally the most versatile and efficient. Recent advanced innovations in design and operation, as outlined in previous paragraphs, add to an already proven record of reliability.

Operating Characteristics

Operating Depths: Minimum dredging depths range from 3 to 14 feet depending on series or model size. Maximum dredging depths range from 12 to 65 feet. With submerged dredge pumps dredging depths have been increased to 100 ft. Lateral dredging accuracy is within 2 to 3 feet. The draft of the vessel ranges from 3 to 5 feet as shown in the tabulation of general characteristics by size in preceeding paragraphs. Limiting wave height is 3 feet.

Percent Solids in Slurry by Weight: Slurries of 10-20 percent are typical for rotary types. A pipeline concentration of 13 percent by dry weight (145 parts per thousand) is sometimes used for design. A new improved bucket wheel is reported to provide up to 50 percent solids, by weight.

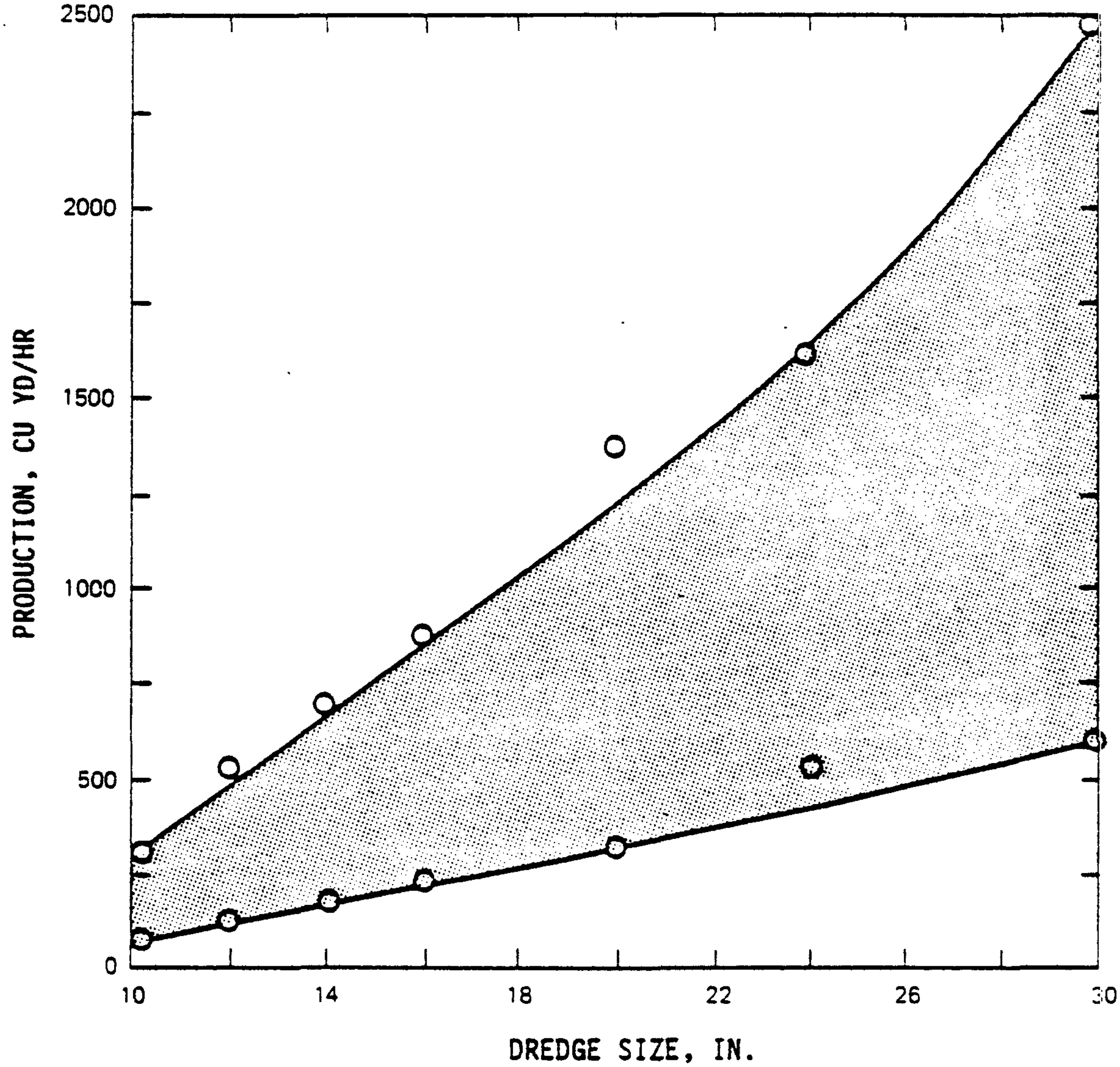
Production Rate: The range for typical cutterhead production as a function of dredge size is shown in Figure C-1. The relationships of solids output, dredge size, and pipeline length at various dredging depths are shown in Figure C-2. These relationships can be used as a preliminary selection guide for the size of dredge to be used.

A possible size consideration for the upper Acushnet River Estuary would be a 10-inch diameter suction and 10-inch discharge pipe which would have an approximate capacity as follows:

- Dredge pump capacity 2,250 gpm at 190 feet of head.
- Cutter horsepower, 40 hp.
- Digging depth to 20 feet.
- Production rate of 250 cu yd/hr, or 1.12 million cu yd per year.
- Pumping distance to 1,000 feet.

Sediment Resuspension Due to Cutterhead Dredging: Resuspension of sediments as indicated by turbidity is rated as average on a scale of high to low as compared with other types of dredges. Elevated levels of suspended material are localized in the immediate vicinity of the cutter. Within 10 feet of a rotary cutter, concentrations may be as high as a few tens of parts per thousand. Near-bottom suspended solids concentrations may be elevated to levels of a few tenths of parts per thousand at distances of less than 1000 feet from the cutter.

Legal/Institutional Constraints: There are no legal or institutional constraints for the use of the cutterhead type of dredge on this project.



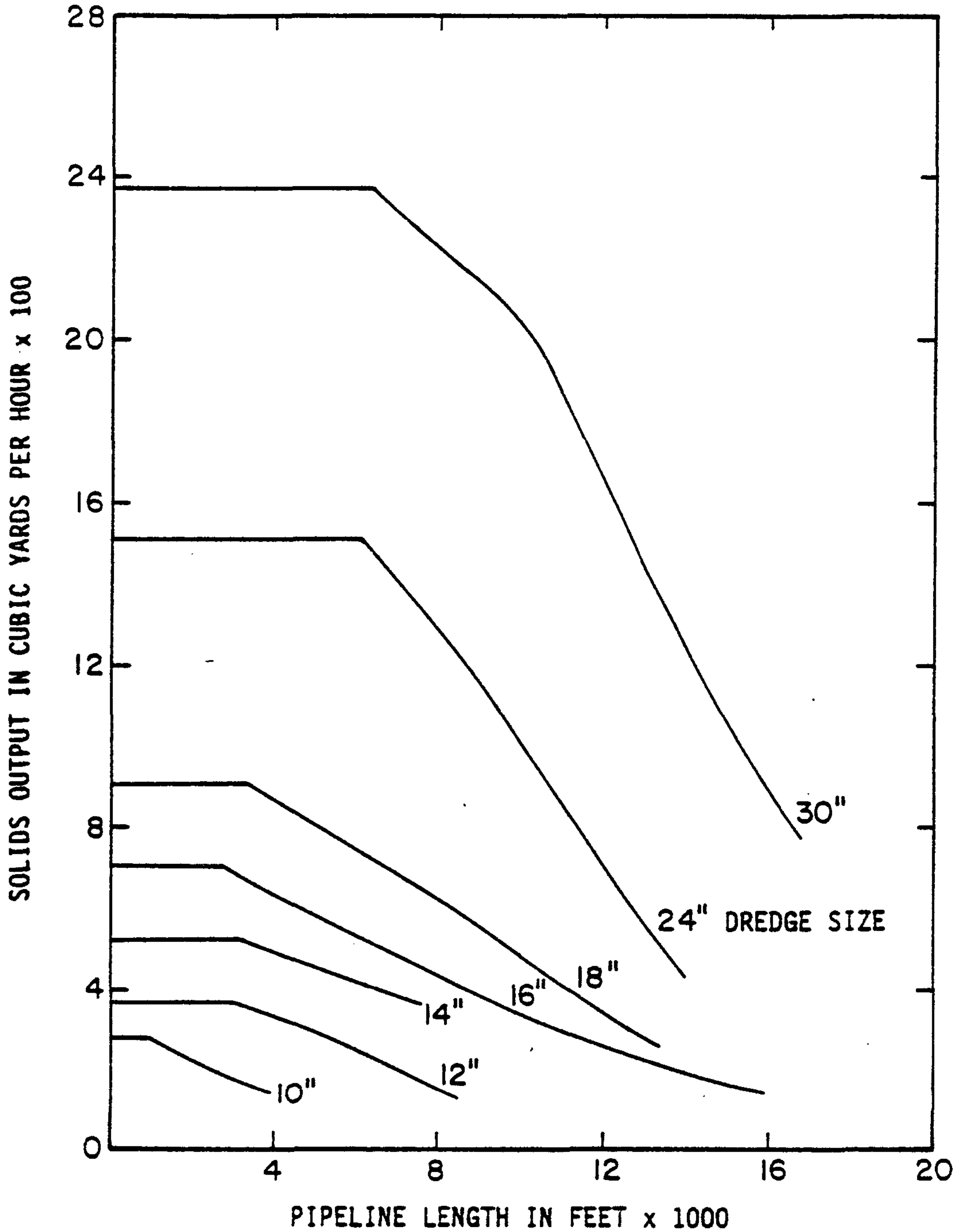
Reference Source:

Headquarters Department of the Army (HQDA), 1983. "Dredging and Dredged Materials Disposal," Engineer Manual EM 1110-2-5025, Washington, D.C.

FIGURE C-1

TYPICAL CUTTERHEAD DREDGE PRODUCTION
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company



DREDGING DEPTH OF 20 FT

Reference Source:

Headquarters, Department of the Army (HQDA). 1983. "Dredging and Dredged Material Disposal," Engineer Manual EM 1110-2-5025, Washington, D.C.

FIGURE C-2

CUTTERHEAD DREDGE SOLIDS OUTPUT CURVES
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company

Site Specific Applicability: For contaminated sediments good operating techniques must be maintained. Both the rotary and bucket wheel types of hydraulic pipeline cutterhead suction dredge are well suited for the upper Acushnet River site as indicated by the following considerations:

- A wide range of sizes permits selection of an efficient model to meet draft limitations, depth and other operating requirements.

- The hydraulic pipeline is ideal for transporting contaminated dredged material to the containment basin.

- New advanced equipment has improved operations relating to environmental concerns.

Cost of Dredging: The dredging cost is estimated to be $5.40 per cubic yard.

C.4.3 Horizontal Auger-Cutter Dredge ("Mud Cat" and Others)

General Description of Dredge and of Operation

The horizontal-cutter also combines both mechanical and suction dredging. The auger-cutter assembly dislodges and delivers the material to the pump suction intake. Liquid carries the solids through the intake to the centrifugal pump which adds pressure to the slurry mixture when confined in the pipeline. The slurry mixture of solids and liquid flows through the pipeline to a containment (settling pond) where it is discharged. Excavated material includes silt, sand, muck, weeds, sludge and industrial wastes.

The anchoring system is by winch and cable. Materials are excavated as the machine moves in both the forward and reverse directions. Several passes are normally required in the same cut to excavate underwater materials to the required depth. When all of the material is excavated in a given cut, a "pullover" is made to laterally reposition the guide cables and the procedure is repeated. This is done until the project is completed. The average cuttting speed is 8 to 12 feet per minute.

In general, horizontal cutter machines are compact and portable. They are designed to hydraulically remove sediments from waterways such as rivers and streams and from impoundments such as lakes, settling ponds, and industrial lagoons. The size and working capacity is usually less than that available from the rotary cutterhead type as previously discussed. Cutterhead types and the horizontal auger-cutter dredge are illustrated in Figures C-4 and C-5.

General Characteristics (Horizontal Cutter)

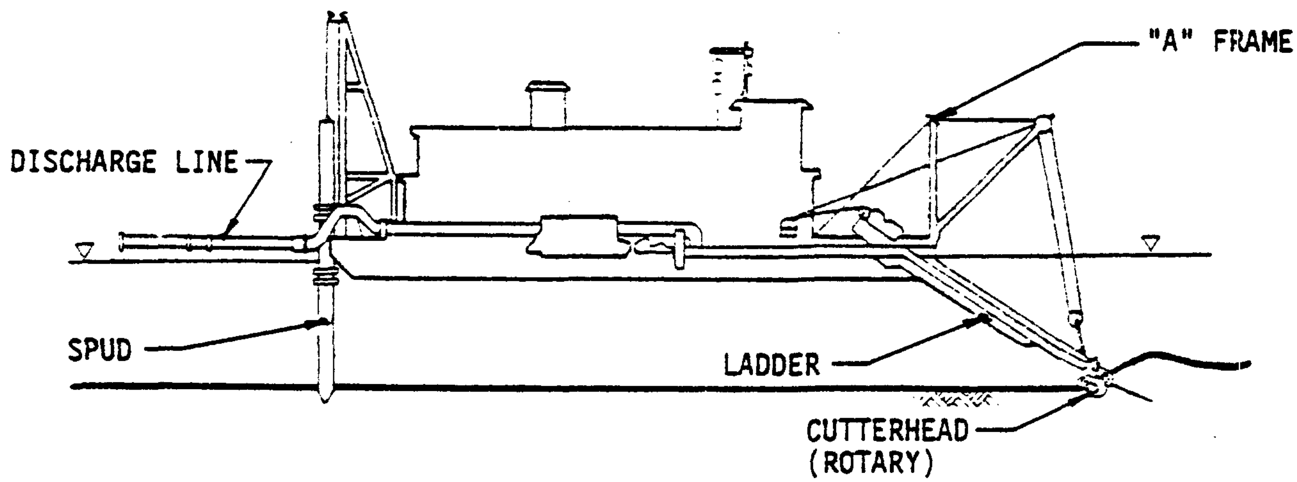
Dimensions: Typical dimensions and related information are tabulated for three suction pipline sizes as follows:

Pipeline Diameter in.	Weight tons	Length ft.	Cutter Width ft.	Draft ft.	Maximum Depth of Single pass Excavation ft.	Production Rate cu yd/hr
8	10.5	39	9	1.75	1.5	to 120
10	12.5	48	9	1.75	1.5	to 180
12	11.5	41	8	1.67	1.5	to 200

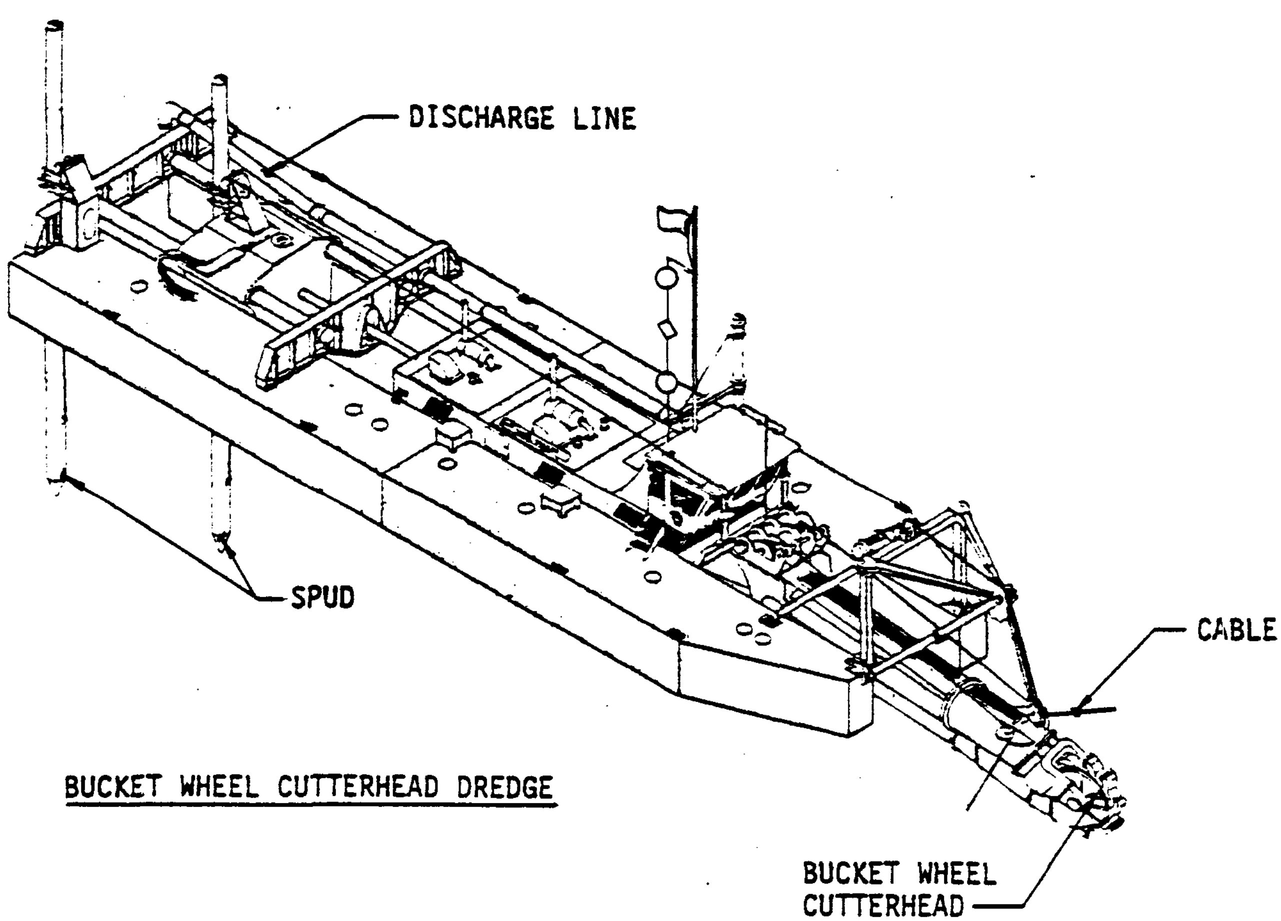
Mobilization/Demobilization: The dredge is transported as a complete unit on 40-foot flatbed trailer; 20 ton crane needed to unload.

Special Equipment: Optional accessories include: weed cutting auger, auger wheel and auger cage assemblies, interchangeable cutting knives and anodes for salt water applications.

Equipment Availability: The horizontal cutter type dredge is readily available.



ROTARY CUTTERHEAD DREDGE

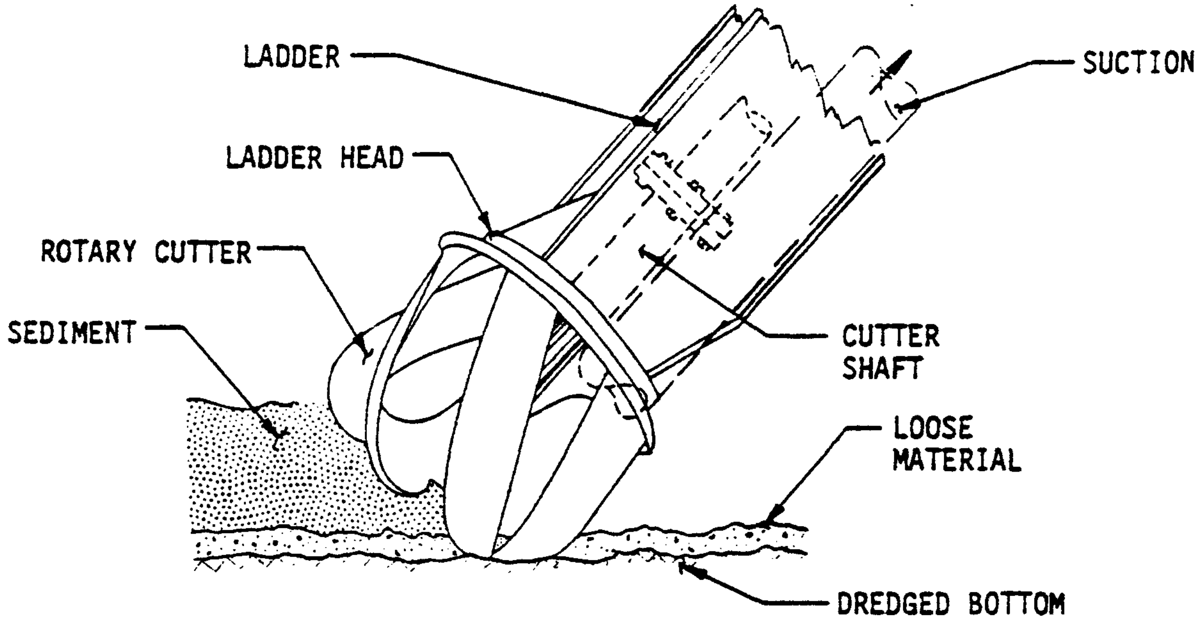


BUCKET WHEEL CUTTERHEAD DREDGE

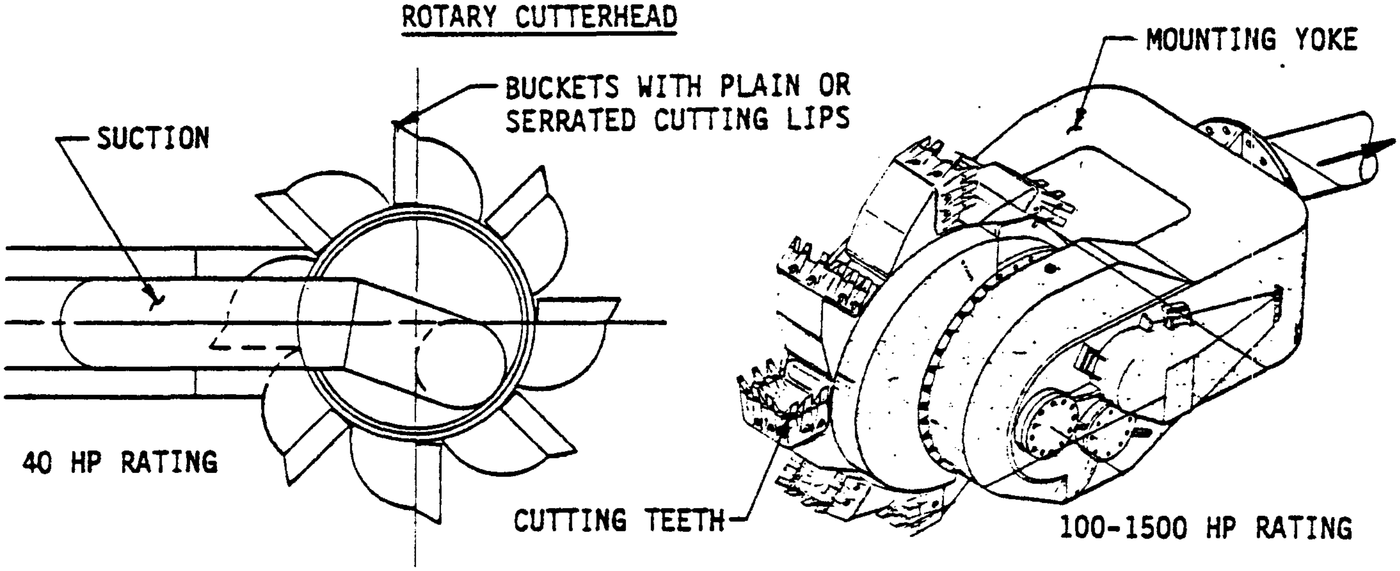
FIGURE C-3

ROTARY AND BUCKET WHEEL DREDGES
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

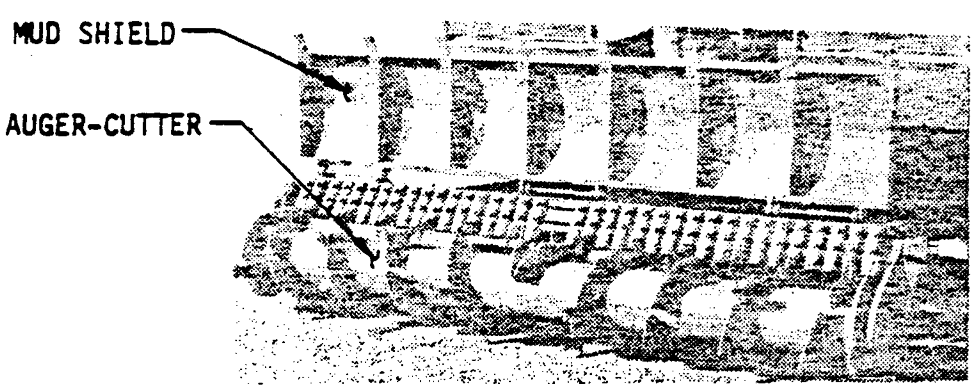
NUS CORPORATION
A Halliburton Company



ROTARY CUTTERHEAD



BUCKET WHEEL CUTTERHEAD

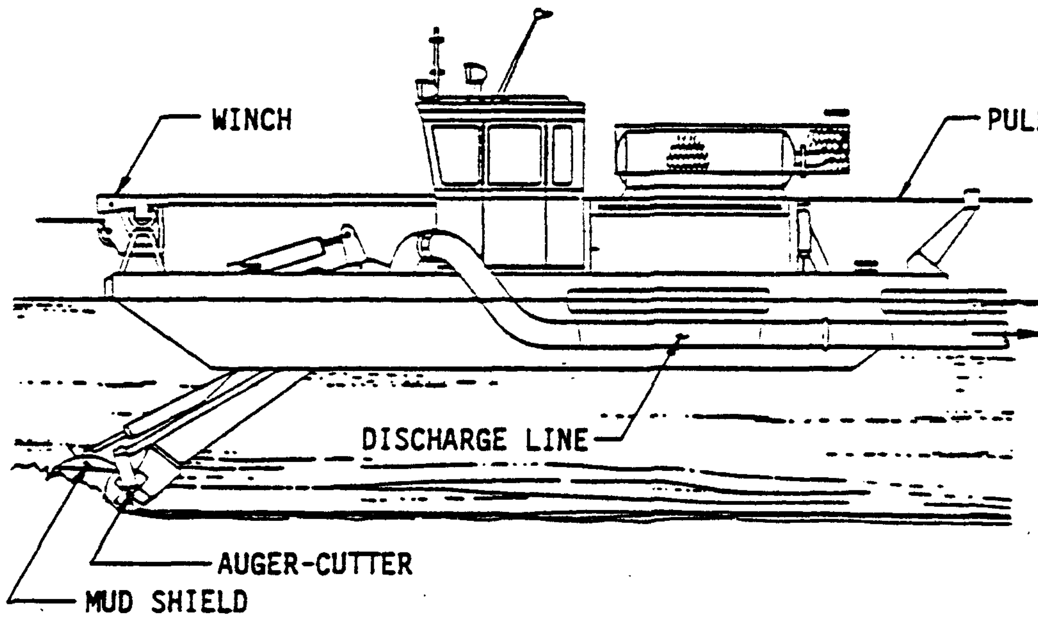


HORIZONTAL AUGER-CUTTER

FIGURE C-4

CUTTERHEAD TYPES
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company



HORIZONTAL AUGER-CUTTER DREDGE

FIGURE C-5

HORIZONTAL AUGER-CUTTER DREDGE
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company

Technical Feasibility: This type of dredge has a past proven record of performance and is used extensively in the United States and other countries throughout the world.

Operating Characteristics (Horizontal Cutter)

Operating Depths: Operating depths are from zero to 15 feet and from zero to 20 feet. The maximum single pass depth is eighteen inches. The limiting wave height is less than two feet.

Percent Solids in Slurry by Weight: The average solids content is listed as 10 to 20 percent. However, some manufacturers claim up to 50 percent solids in the slurry.

Production Rate: The relationships of solids output, dredge size and pipeline length for the dredging depth as shown in Figure C-2 also apply to horizontal cutters. Possible production values for a 10-inch diameter size horizontal cutter dredge are suggested as follows:

- Dredge pump capacity, 2,250 gpm at 160 feet of head
- Cutter horsepower, 35.5 hp
- Digging depth to 15 feet
- Production to 200 cu yd/hr.
- Pumping distance to 1,000 ft.

Sediment Resuspension (Horizontal Cutter): Resuspension of sediments is rated as average to low as compared to turbidity values created by other types of dredges. Shrouds are available for the auger-cutter.

Legal/Institutional Constraints: There are no legal or institutional constraints for use of the horizontal auger-cutter dredge.

Site Specific Applicability: The hydraulic pipeline horizontal auger-cutter dredge is suited for the upper Acushnet River site as indicated by the following considerations:

- The hydraulic pipeline is ideal for transporting contaminated sediments to the containment basin.
- The horizontal auger-cutter, which is 9 feet wide, gives good area coverage for excavating and removing sediments. Even though the production capacity of current models is low, it is possible to use more than one machine within the confines of the project.
- Low solids resuspension and new advanced equipment relating to environmental concerns are plus factors for the equipment.
- Maneuverability and low draft are suitable to this confined site.

Cost of Dredging: The dredging cost is estimated to be $5.40 per cu. yd.

C.4.4 Plain Suction Hydraulic Pipeline Dredge

General Description of Dredge and of Operation

As the name implies, this dredge operates by the suction mechanism. It is similar to the cutterhead dredges previously described except for the absence of the cutter at the intake end of the suction pipe. This equipment is used to dredge loose and free-flowing sediments such as encountered in maintenance work. Large volumes of free-flowing material can be excavated economically. However, this type of dredge would have a limited use for new construction in a waterway where a variety of sediments exist or if sediments are compacted.

The general and operating characteristics as well as the cost for dredging as outlined previously for the cutterhead dredges apply to the plain suction dredge. Both the plain suction and the dustpan dredges are illustrated in Figure C-6.

C.4.5 Dustpan Dredges

General Description of Dredge and of Operation

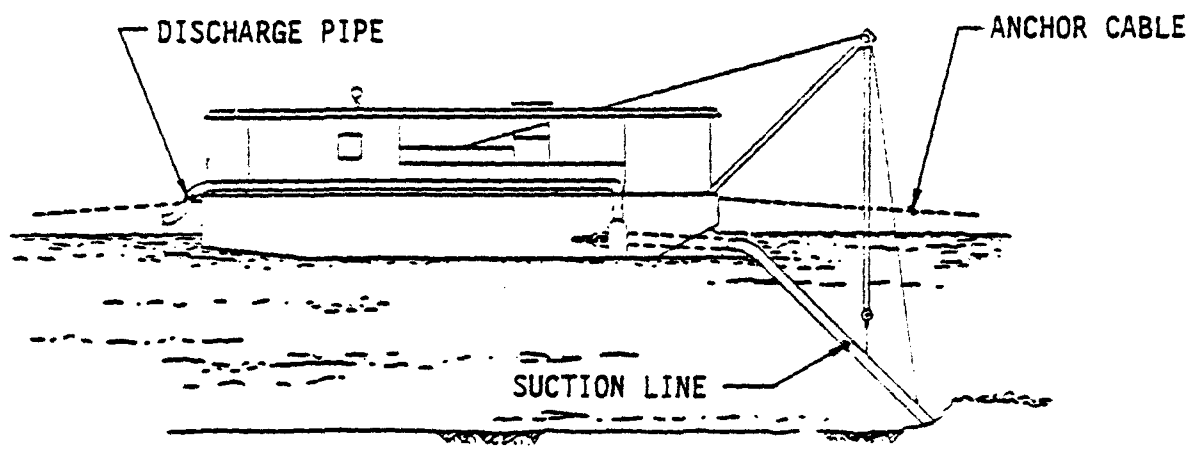
The dustpan dredge is a hydraulic suction dredge that uses a widely flared dredging head along which are mounted pressure water jets. The jets loosen and agitate the sediments which are then captured in the dustpan head, as the dredge itself is winched forward into the excavation. The dustpan dredge maintains navigation channels by making a series of parallel cuts through the shoal areas until the required widths and depths are obtained. The dredged material is normally discharged to open water adjacent to the dredged navigation channel through a pipeline of usually only 800 to 1,000 feet long.

The dustpan dredge is self-propelled, which enables it to move rapidly over long distances to work sites. The attendant plant and pipeline are designed for quick assembly. Actual dredging operations are controlled by cables and winches. The dredge is equipped with a low-head, high capacity pump.

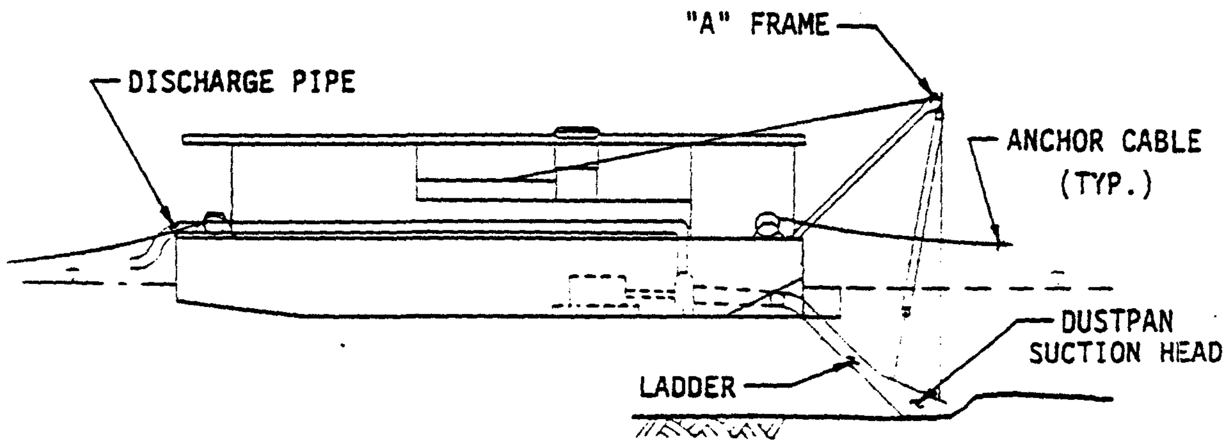
The dustpan dredge was designed for a particular purpose, and for this reason there are certain limitations to its use in other dredging environments. It can dredge only loose materials such as sands or gravels and only in sheltered waters where little wave action is expected. Pumping to upland areas would require booster pumps and additional pipe.

General Characteristics

Dimensions: Typical dimensions are 32-inch pipeline diameter, 244-feet length and 50-foot width. The draft is 5 feet, dredging depth is 60 feet and the maximum depth of single pass excavation is 5 feet.



PLAIN SUCTION DREDGE



DUST PAN DREDGE

FIGURE C-6

PLAIN SUCTION AND DUSTPAN DREDGES
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company

Mobilization: The dustpan dredge is self-propelled for use in navigation channels. It is not portable for land transportation.

Special Equipment: The dustpan dredge is self-contained. Booster pumps and extra pipe would be required for upland or long distance transport of dredged materials.

Availability: The dustpan dredge has limited availability.

Technical Feasibility: This type of dredge was developed to maintain navigation channels in uncontrolled rivers with bedloads consisting primarily of sand and gravel. Since it can dredge only loose materials its use for new work excavation of compacted sediments would not be practical. The equipment is durable and reliable and is suited to the purpose for which it was designed.

Operating Characteristics

Operating Depths: A typical size dustpan dredge is 244 feet long by 50 feet wide with a 32-inch diameter suction pipe. The dredging depth extends to 60 feet. The maximum depth of single pass is 5 feet. The vessel has a draft of 5 to 14 feet. The limiting wave height is less than three feet.

Percent Solids in Slurry by Weight: The normal working range is 10 to 20 percent solids in the slurry.

Production Rate: Dustpan dredges are high-volume dredges with an approximate range of production from 1200 to 5700 cubic yards per hour.

Sediment Resuspension: Resuspension of sediments as indicated by turbidity is rated as average on a scale of high to low as compared to other types of dredges.

Legal/Institutional Constraints: There are no legal or institutional constraints for use of the dustpan dredge at New Bedford.

Site Specific Applicability: The dustpan dredge is not suitable for use in the upper Acushnet River because of the following considerations:

- There is no navigable access into the upper river for the dustpan dredge vessels. In addition, the draft of the vessel exceeds the shallow depth of the work area.

- The dustpan can dredge only loose materials such as sands and gravels.

- Pumping distances are limited to about 1000 feet without the use of booster pumps.

Cost of Dredging: The cost of dredging with a dust plan dredge is estimated to be $5.00 per cu. yd.

C.4.6 Hopper Dredges

General Description of Dredge and of Operation

Hopper dredges are self-propelled seagoing ships of from 180 to 550 ft. in length. They are equipped with propulsion machinery, sediment containers (hoppers), dredge pumps, and other special required equipment. Dredged material is raised by dredge pumps through drag arms connected to drags in contact with the channel bottom and discharged into hoppers contained in the vessel. Large class dredges have hopper capacities of 6,000 cu yd or greater; medium-class hopper dredges have hopper capacities of 2,000 to 6,000 cu yd; and small-class hopper dredges have hopper capacities of from less than 2,000 to 500 cu yd. For an illustration of the hopper dredge, see Figure C-7, included in the succeeding clamshell dredge section.

Dredging is accomplished by progressive traverses over the area to be dredged at speeds up to 3 mph. Hopper dredges can dredge in depths from 10 to over 80 feet. Once fully loaded, hopper dredges move to the disposal site to unload before resuming dredging. Unloading is accomplished either through the bottom of the hoppers at open-water disposal sites or by pumping the dredged material to confined disposal sites. Because of limitations (environmental) on open-water disposal, most hopper dredges have direct pumpout capability for disposal in confined sites.

Hopper dredging is accomplished by three methods: (1) pumping past overflow, (2) pumping to overflow, and (3) agitation dredging. Agitation dredging does not have application to the contaminated sediments of the Acushnet River Estuary and will not be discussed further. When contaminated sediments are to be dredged and adverse environmental effects have been identified, pumping past overflow is not recommended. In such cases other types of dredges may be more suitable. If hopper dredges are not allowed to pump past overflow in sediments that have good settling properties, the cost of dredging increases.

Hopper dredges are used mainly for maintenance dredging on shipping channels where traffic and operating conditions rule out the use of stationary dredges. Hopper dredges are most efficient in excavating loose, unconsolidated materials.

General Characteristics

Dimensions: Small, medium, and large sizes (classes) based on hopper capacity range from 500 cu yd to 8,500 cu yd. The length and width vary from 180 ft by 38 ft to 550 ft by 80 ft.

Mobilization/Demobilization: Hopper dredges are designed as seagoing ships with molded hulls and lines of ocean vessels. They are not land portable.

Special Equipment: Specifically designed drags are available for use in raking and breaking up hard materials, however hopper dredges are most efficient in excavating loose, unconsolidated materials. Most models have direct pumpout capability. Upland disposal would require material transport such as truck or hydraulic pipeline with booster pumps. Drags are not suited for aquatic vegetation.

Equipment Availability: Hopper dredges are of limited quantity because of size and areas of required demand.

Technical Feasibility: Hopper dredges are reliable for the use intended. However, this dredge is not technically feasible for the non-navigable upper Acushnet River estuary.

Operating Characteristics

Operating Depths: Hopper dredges have a deep draft (12 ft to 31 ft), which precludes use in shallow waters. The maximum dredging depth ranges from about 35 feet to 80 feet. The minimum depth range is 10 to 28 feet. The hopper dredge excavates with less precision than other types of dredges having a lateral accuracy of 10 feet. Vertical accuracies are generally one foot, plus or minus. Limiting wave height is seven feet. Limiting current is about seven knots.

Percent Solids by Slurry by Weight: This value ranges from 10 to 20 percent.

Production Rates: The approximate range of production is rated at 500 to 2,000 cubic yards per hour, depending on the size of the hopper dredge.

Sediment Resuspension: Resuspension of fine-grained dredged material during hopper dredging operations is caused by the dragheads as they are pulled through the sediment, turbulence generated by the vessel and its prop wash, and overflow of turbid water during hopper filling operations. A near-bottom turbidity plume of resuspended bottom material may extend to 2,400 feet down current from the dredge. At the dredge, a well-defined upper plume is generated by the overflow process which could extend up to 1000 feet behind the dredge. Suspended solid concentrations above ambient may be as high as several tens of parts per thousand (grams per liter) at the vessel and as high as a few parts per thousand near the draghead.

Site Specific Applicability: The hopper dredge is not suited for use in the non-navigable upper Acushnet River estuary for several reasons. It should not be considered further.

C.4.7 Clamshell Dredges

General Description of Dredge and of Operation:

A clamshell dredge is a clamshell type of excavation bucket attached to a crane by operating cables which manipulate the bucket as controlled by the crane operator. Other excavation buckets include the orangepeel and dragline types which can be changed on the dragline to suit operational requirements. The clamshell bucket has been widely used for dredging. A special bucket has been developed for dredging contaminated sediments.

To minimize turbidity generated by a clamshell operation, watertight buckets have been developed. The edges seal when the bucket is closed and the top is covered to minimize loss of dredged material. Clamshell dredges may be used to dredge most types of material except for the most cohesive consolidated sediments and solid rock. Buckets are best adopted for maintenance dredging of fine-grained material.

The crane is mounted on a flat-bottomed barge, on fixed-shore installations, or on crawler mount. A barge mounted clamshell dredge is not self-propelled but can move itself over a limited area during the dredging process by manipulation of spuds and anchors. A typical sequence of operation is as follows:

- The bucket dredge, scows or hopper barges, and attendant plant are moved to the work site by a tug.

- The dredge is positioned at the location where work is to start and the anchors and spuds lowered into place.

- A scow or hopper barge is brought alongside and secured to the bucket dredge hull.

- The dredge begins the digging operation by dropping the bucket in an open position from a point above the sediment. The bucket falls through the water and penetrates into the bottom material. The sides or jaws of the bucket are then closed through the use of wire cables operated from the crane. As the sides of the bucket close, material is sheared from the bottom and contained in the bucket compartment. The bucket is raised above the water surface and swung to a point over the hopper barge. The material is then released into the hopper barge by opening the sides of the bucket.

- As material is removed from the bottom of the waterway to the desired depth at a given location, the dredge is moved to the next nearby location by using anchors. If the next dredging area is a significant distance away, the bucket dredge must be moved by a tug.

- The loaded barges are towed to the disposal area by a tug and emptied by bottom dumping if an open water disposal area is used. If a diked disposal area is used, the material must be unloaded using mechanical or hydraulic equipment.

- These procedures are repeated until the dredging operation is completed (For illustration see Figure C-7).

General Characteristics

Dimensions: Available sizes of the clamshell bucket range from 2.6 to 26 cubic yards.

Mobilization/Demobilization: The sizes of dredge required of New Bedford would be transportable by truck or barge to the site. Take-down of the crane would be required. Crawler mounted cranes would be self propelled, but barge mounted cranes would require tugs for long distance mobility.

Special Equipment: Special buckets would be required for the excavation of contaminated sediments. No provision is made for dredged material containment or transport, so the clamshell dredge must work alongside the disposal area or be accompanied by disposal barges during the dredging operations.

Equipment Availability: The clamshell dredge would be easily available for the New Bedford project.

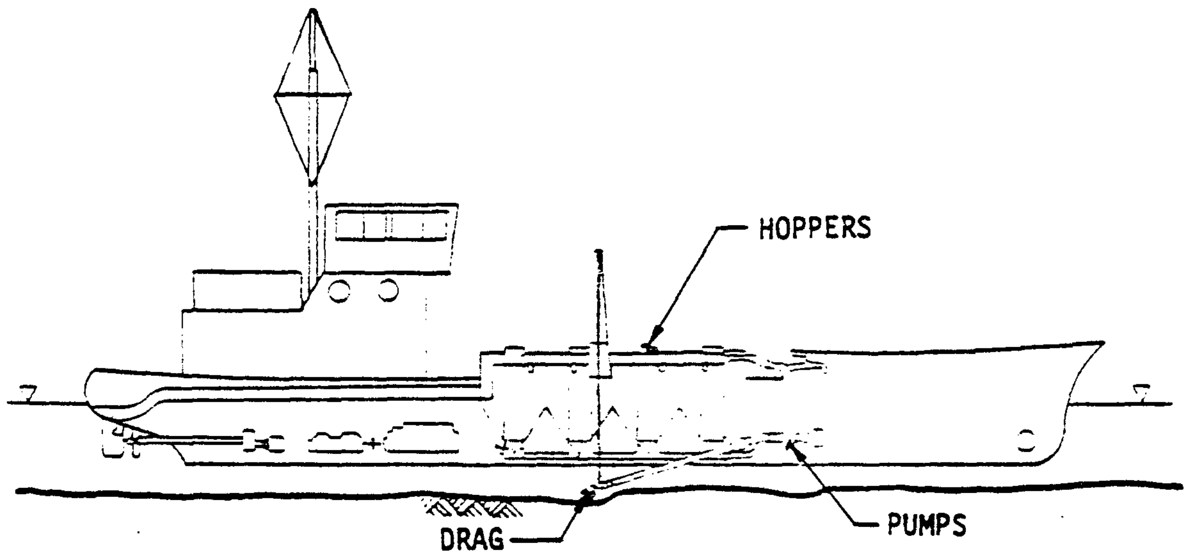
Technical Feasibility: The reliability of the clamshell bucket has long been proven for sediment excavation. The clamshell dredge is effective around bridges, docks, wharves, pipelines, piers, or breakwater structures because it does not require much area to maneuver and the dredging process can be controlled accurately.

Operating Characteristics

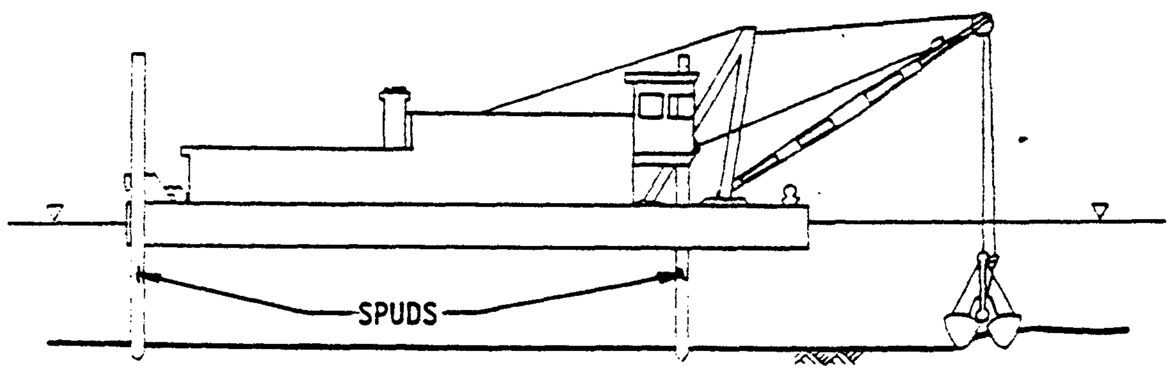
Operating Depths: The demonstrated dredging depth is from zero to 100 feet. (Zero if dredge is used along side of waterway; otherwise the draft of the vessel will decide). The vessel draft depends on the floating structure; if barge-mounted, five to six foot draft.

Percent Solids: The density of the material excavated is about the same as the inplace density of the bottom material. Therefore the volume of excess water is minimal, which increases the efficiency of operation in the transportation of material to the disposal area.

Production Rate: Clamshell buckets range in size from 1 to 12 cubic yards. Twenty to thirty cycles per hour is typical, but large variations exist in production rates because of the variability in depths and material being excavated. The approximate range in production rates vary from 30 to 500 cubic yards per hour.



HOPPER DREDGE



CLAMSHELL DREDGE

FIGURE C-7

HOPPER AND CLAMSHELL DREDGES
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company

Sediment Resuspension: Resuspension of sediments as indicated by turbidity is rated as high for the clamshell dredge on a scale of high to low as compared to other types of dredges. Leakage of dredged materials from the special watertight clamshell bucket is 35 percent less than leakage from the typical clamshell bucket. A watertight bucket generates 30 to 70 percent less turbidity in the water column than the typical bucket.

Legal/Institutional Constraints: There are no known legal or institutional constraints to the use of the clamshell dredge on the New Bedford project.

Site Specific Applicability: The upper Acushnet River channel is not navigable. This would exclude the use of barges for mounting of the clamshell dredge and for transporting of dredged materials. To be used at this site the clamshell dredge would require a crawler mount and use may be limited to shoreline or wharf areas. The low production as compared to other types of dredges may not be conducive to excavating the entire upper area.

Cost of Dredging: The cost of dredging with a clamshell dredge is estimated to be $7.00 to $8.00 per cu. yd.

C.4.8 Airlift Dredges

<u>General Description of Dredge and of Operation</u>

The operation of the airlift principle as applied to dredging is basically as follows: compressed air is forced into the lower end of a vertical conveying tube (dredging pipe). The resulting decrease in density causes an upward movement of the water column in the water-filled tube. The vertical movement of the water column is used as a drive for the conveyance of the solids.

The object of the dredge is to convey solids from various water depths to small heights above the water.

The dredging pipe diameter is sized to meet performance requirements, working depths and materials to be dredged. Each pipe diameter is assigned a specific quantity of air (optimum ratio) to be supplied. The production plant for the compressed air must be properly sized to meet the requirements of the operation.

For a continuous and good performance of the solids at an optimum air ratio two provisions are required: (1) the compressed air must be directed into the circumference of the dredging pipe in uniform and fine air bubbles, and (2) the solids to be conveyed must be well suspended before entering the dredging pipe. To meet these requirements a hydraulically driven rotating head is attached to the lower end of the dredging pipe. A cutting attachment to the rotating head helps suspend the solids. The suspension of solids is further increased by a spraying device located at the rotary head. When dredging mud and very fine materials, the suspension of the solids with spray water is very important. Due to the whirl-up effect of these water jets a slurry mixture containing up to 50 percent solids can be achieved.

The dredging pipe is mounted in a vertical position having a working stroke of 15 to 25 feet. At the top of the dredging pipe the flowing dredged material is directed into a feeding shaft by a bend, which is lined with wear resistant rubber. This feeding device serves as a release of the compressed air from the slurry and also absorbs the vertical power stroke.

According to circumstances and function, the discharging from the feeding shaft can be effected in the following three ways:

- Draining the water from the solids to achieve transport capability of the solids. (This can be performed by a bucket wheel equipped with screens or a pre-straining installation with a cyclone plant).

- Charging of transport barges for direct flashing.

- Charging a sump for hydraulic pipeline transportation of the solids.

The use of the airlift dredge for the recovery of sand and gravel from inland waters uses the tried dewatering bucket wheel for drainage. The solids are then transported by floating conveyor belts, within distance limitations. Whenever hydraulic pipeline transportation is used a sump is charged by the feeding shaft. This sump insures the most favorable solids-water mixture for the hydraulic conveyance. If required, additional water for conveyance can be added to the sump for the pump.

For the upper non-navigatable Acushnet River Estuary the transporting of the dredged material by barges would be limited. Drainage of the material at the dredge for transport by conveyor belt would also be excluded. Hydraulic pipeline conveyance is the most economic and practical method of transporting the dredged material. A sketch of the airlift dredge is shown in Figure C-8.

General Characteristics

Dimensions: The airlift dredge is made-up of 6 to 7 modular units, each mounted on pontoons and all coupled together for the dredging operation. The dredge may be set up as a single unit or as a double unit complete with two air compressor plants and measuring 80 by 70 feet. The draft is about 5 feet.

Mobility/Demolition: The dredge would be transported in its several parts by trucks and assembled at the work site.

Special Equipment: For hydraulic pipe line conveyance the sump-with-pump attachment would be required including the necessary length of floating pipeline.

Equipment Availability: This dredge is manufactured in the United States and may require up to 6 months to obtain on order.

Technical Feasibility: Sturdily constructed equipment assures high operating efficiency. The dredge operates on a very simple process and is centrally controlled. Manufacturers claim almost unlimited application, such as sand and gravel recovery from lakes and rivers and mud from ponds. The rotary conveying head with a cutting adapter has operated successfully in firm and solid layers of materials such as clay and loam inclusions. The primary use has been for the recovery of sand and gravel from unlimited depths.

Operating Characteristics

Operating Depths: Dredging depths up to 300 feet have been reached. The vertical working stroke extends up to 15 to 25 feet. Published minimum depths were not known at this writing.

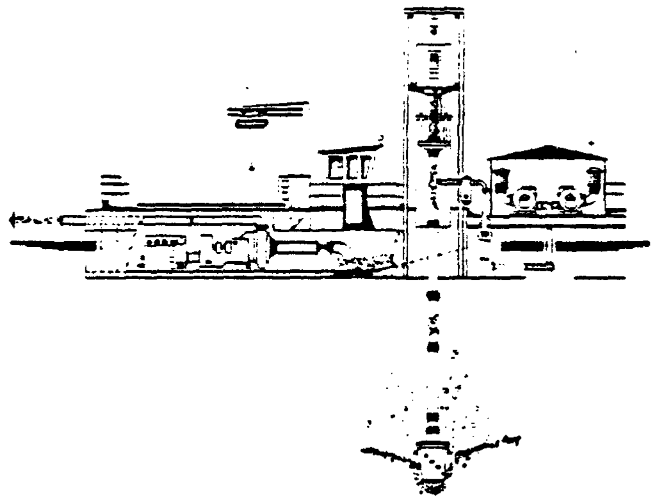
Percent Solids in Slurry: Under ideal conditions slurry mixtures up to 50 percent solids are possible. The solids content can be adjusted at the sump pump if required to facilitate conveyance through the pipeline.

Production Rate: Production rates of 400 cubic yards per hour for a single unit and up to 1,000 cubic yard for hour for a double unit at depths up to 260 feet are possible.

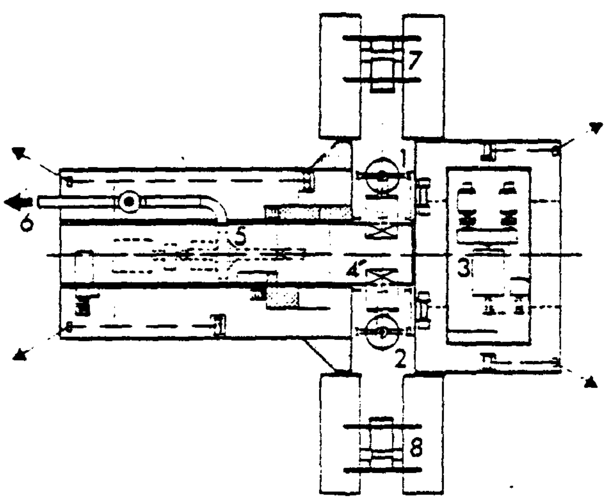
Sediment Resuspension: Resuspension of sediments as indicated by turbidity is noted as average to low.

Legal/Institutional Constraints: This dredge is manufactured in the United States. The air compressor component in some modules may be of foreign manufacture. There is no legal restraint for use of the type of dredge.

Site-Specific Applicability: The shallow depths of the upper Acushnet River Estuary may be restrictive to the use of the airlift dredge. Since the dredging tubes are mounted vertically the dredge plant is located directly over the dredging head. This position does not allow excavating into shallow shore areas because of draft requirements. Also the operation of this dredge at depths of less than 5 to 10 feet is questionable.



SCHEMATIC OF THE COMPRESSED AIR DREDGE IN OPERATION



SECTIONAL DRAWING OF A COMPRESSED AIR DOUBLE PLANT WITH FLUSHING DEVICE FOR HYDRAULIC CONVEYANCE.

1. DREDGING LINE #1: 2. DREDGING LINE #2: 3. PRODUCTION PLANT FOR COMPRESSED AIR: 4. SUMP: 5. ARMOR PUMP AGGREGATE: 6.DISCHARGE LINE: 7. HOISTING DEVICE FOR DREDGING LINE #1: 8. HOISTING DEVICE FOR DREDGING LINE #2.

FIGURE C-8

AIRLIFT DREDGE
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company

Cost of Dredging: The cost of dredging with the air lift dredge is estimated to be $6.50 per cu. yd.

C.4.9 "Amtec" (Pneumatic) Dredge

General Description of Dredge

A pneumatic dredge has a pneumatic pump chamber as a dredge head. Entrance of sediments into the pump chamber is through a cylinder at the base of the pump. Actually to obtain continuous and smooth flow of dredge material, two or three cylinders are used in a sequential mode of operation. This pneumatic device is operated by compressed air.

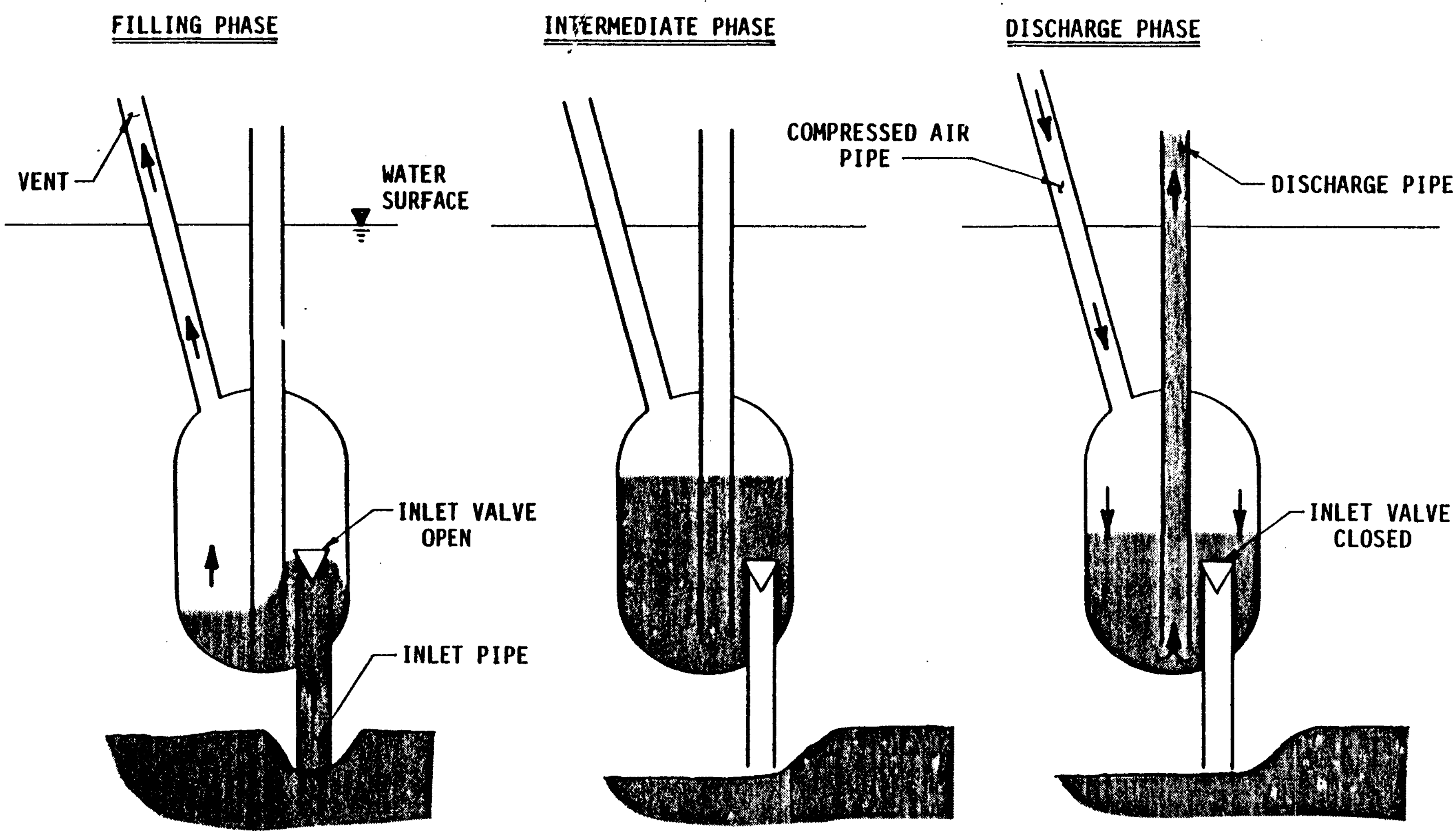
The operation principle of the pneumatic pump is illustrated in Figure C-9. During the dredging process, the pump is submerged and sediment and water are forced into one of the empty cylinders through an inlet valve. After the cylinder is filled, compressed air is supplied to the cylinder, forcing the water out through an outlet valve. When the cylinder is almost empty, air is released to the atmosphere, thus producing atmospheric pressure in the cylinder. A pressure difference occurs between the inside and outside of the cylinder, creating a suction that forces the sediment into the cylinder. When the cylinder is filled with sediment, compressed air is again pumped into the cylinder to expel the sediment from the cylinder.

The "Amtec" system has added refinements to the above process which includes a vacuum system to increase production.

The total plant and equipment would be supported by barge or pontoons similar to that previously described for the airlift dredge. A booster pump at the dredge plant would be required for hydraulic pipeline transport of dredged material.

Site-Specific Application: This type of dredge would be suitable for "hot-spot" dredging. However, its use in shallow depths is not fully known.

Cost of Dredging: The cost of dredging with the pneumatic "Amtec" dredge is estimated to be $6.40 per cu. yd.



OPERATING CYCLE OF PNEUMATIC PUMP

C-49

FIGURE C-9

PNEUMATIC TYPE DREDGE
NEW BEDFORD HARBOR FEASIBILITY STUDY
NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company